APPENDIX D

RESPONSES TO PUBLIC COMMENTS

PALOS VERDES REEF RESTORATION PROJECT

PREPARED BY THE VANTUNA RESEARCH GROUP AT OCCIDENTAL COLLEGE IN COORDINATION WITH THE MONTROSE SETTLEMENTS RESTORATION PROGRAM

TABLE OF CONTENTS

APPENDIX D1

RESPONSES TO PUBLIC COMMENTS:
PUBLIC COMMENT PERIOD, FEBRUARY 21 TO MARCH 22, 2017

PREPARED BY THE VANTUNA RESEARCH GROUP AT OCCIDENTAL COLLEGE
IN COORDINATION WITH THE
MONTROSE SETTLEMENTS RESTORATION PROGRAM

Public Comment Summary and Responses

Prepared by the Vantuna Research Group at Occidental College in coordination with MSRP

Table 1. Summarized information regarding those who contacted either the National Oceanic and Atmospheric Administration (NOAA)/Montrose Settlements Restoration Program (MSRP) or California State Lands Commission (CSLC), including the "Contact No." referenced in Table 2.

Contact No.	Contact Date	Name of Contact	Title	Represented Group
1	2/16/17	Jim MacLellan	Resident	Rancho Palos Verdes
2	3/3/17	Lili Amini	General Manager	Trump National Golf Course
3	3/6/17	Jim Randall	Resident	Rancho Palos Verdes
4	3/6/17	Marc Schwarting	Resident	Rancho Palos Verdes
5	3/7/17	Gary Randall	Resident	Rancho Palos Verdes
6	3/9/17	Robert Marnani	Resident	San Pedro
7	3/10/17	Marianne Hunter William Hunter	Residents	Rancho Palos Verdes
8	3/12/17	Matt Garland	Resident	San Pedro
9	3/16/17	Naoko Munakata	Supervising Engineer	County Sanitation Districts of Los Angeles County (LACSD)
10	3/17/17	Jeff Dorsett	Resident	Rancho Palos Verdes
11	3/17/17	Michelle Ernst	Resident	San Pedro
12	3/17/17	Ray Volman	Resident	San Pedro
13	3/18/17	Gene Dewey	Resident	Rancho Palos Verdes
14	3/18/17	Gary Randall	Resident	Rancho Palos Verdes
15	3/18/17	Tom Kirk	unknown	unknown
16	3/18/17	Kevin Poffenbarger	unknown	unknown
17	3/18/17	Greg Sinclair	unknown	unknown
18	3/19/17	Francisco Bernues	Resident	Rancho Palos Verdes
19	3/19/17	Ken Estrella	unknown	unknown
20	3/19/17	Bill Korakis	Resident	Harbor City
21	3/19/17	Bryce Lowe-White	Resident	San Pedro
22	3/19/17	John Stillo	Resident	Rancho Palos Verdes
23	3/20/17	Bruce V. Rorty	Resident	San Pedro
24	3/20/17	Clayton Kuhlman	Resident (former)	Rancho Palos Verdes
25	3/20/17	Chris Del Moro	Resident	Rancho Palos Verdes
26	3/20/17	<anonymity requested>	Resident	Rancho Palos Verdes
27	3/20/17	Lili Amini	General Manager	Trump National Golf Course
28	3/20/17	Laureen C. Vivian	Resident	San Pedro
29	3/21/17	Jeff Jappe	Resident	Rancho Palos Verdes
30	3/21/17	Jon Jenkins	unknown	unknown
31	3/21/17	John R. Jensen	Resident	Rancho Palos Verdes
32	3/21/17	Sarah Sikich Rita Kampalath Dana Roeber Murray	Vice President Science & Policy Director Marine Scientist & Coastal Policy Manager	Heal the Bay
33	3/21/17	Marty Foster	Resident	Rancho Palos Verdes
34	3/21/17	Kathy Snell	Resident	Rancho Palos Verdes
35	3/21/17	Greg Stanton	unknown	unknown
36	3/21/17	Oliver Hazard	Resident	Rancho Palos Verdes
37	3/22/17	Susan Brooks	Councilwoman	Rancho Palos Verdes City Council
38	3/22/17	Kate Huckelbridge	Senior Environmental Scientist	California Coastal Commission
39	3/22/17	Edmundo Hummel	Resident	Rancho Palos Verdes
40	3/22/17	Ken Dyda	Resident	Rancho Palos Verdes
41	3/22/17	Bill Foster	Resident	Rancho Palos Verdes
42	3/22/17	Dianna Watson	LD-IGR Branch Chief	California Department of Transportation
43	3/22/17	Jessica Vlaco	Resident	Rancho Palos Verdes
44	3/23/17	Charles Hipkins	unknown	unknown
45	3/24/17	Fred Zscheile	Resident	Rancho Palos Verdes
46	4/4/17	Brian Campbell	Mayor	City of Rancho Palos Verdes

Table 2. Summary of comments, responses, and references (where appropriate).

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
Communication and Outreach to Stakeholders				
1	Lack of communication/outreach to stakeholders regarding project	2, 3, 5, 7, 10, 12, 25, 26, 27, 34, 43	Notification of public review of the Environmental Assessment/ Negative Declaration (EA/ND) and the public meeting was sent out on February 21, 2017, by email, directly to 87 members of local, county, state, and federal government, representatives of native tribes, councils, and nations, academic and independent research institutions, and other non-government organizations throughout the region. The notification of the EA/ND and public meeting also followed the noticing requirements pursuant to State California Environmental Quality Act (CEQA) Guidelines section 15072, including publishing in the Los Angeles Times on February 25, 2017. Additionally, outreach regarding this specific project has been ongoing since the release of the MSRP Final Phase 2 Restoration Plan EA in 2012. The public meeting for the plan was announced October 24, 2011, and was held at the Point Vicente Interpretative Center on November 9, 2011.	
2	Public meeting had no presentation and no formal Q&A session	3, 5, 10, 26, 30	The meeting was intended to provide an informal opportunity for stakeholders to ask clarifying questions directly to MSRP staff regarding the EA. In response to public comments, an additional meeting was held on October 11, 2017, at the Pont Vicente Interpretive Center to describe the project in more detail and allow for questions and discussion regarding the reef design and other aspects of this project.	
3	Concern regarding length of public comment period	5, 7	Public comment periods are not a requirement for EAs under the National Environmental Policy Act (NEPA); however, because this was a joint document that includes the ND subject to CEQA, the document was circulated for public review for at least 30 days pursuant to State CEQA Guidelines section 15073.	
4	Concern regarding lack of media coverage	7	We informed the media of the 30-day public comment period and March 2017 informal public meeting, including publishing in the Los Angeles Times on February 25, 2017, and the October 2017 public meeting. The notification of the EA/ND and public meeting followed the noticing requirements pursuant to the California Environmental Quality Act (CEQA) Guidelines section 15072.	
5	Concern regarding rapidly approaching start date	5, 7	The proposed project start date has been moved back one-year from summer/fall 2017 to summer/fall 2018.	
6	Who is in favor/opposed to the project?	7	A list of individuals and representatives who submitted public comments can be found in this document. Of the comments received, 7 commenters were in favor of the project and 38 commenters opposed the project or were critical of at least one aspect of the project design or implementation plan.	

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
7	Environmental Assessment is biased in favor of the restoration reef/reef location	10	The EA was prepared by NOAA and included information from reports and studies written by independent consulting groups. These groups have been studying biological, chemical, geological, and economic aspects of the study region for nearly 40 years, with almost a decade of study on the project area for the purposes of enhancing lost fishing opportunities. Many potential restoration areas were evaluated to achieve the goals of the Phase 2 restoration plan. The proposed project design was determined to be the preferred alternative.	[9; pg 37 – 39]

Support

8	Generally supportive of project	1, 9, 19, 20, 42, 44	General support of the project is acknowledged.	
9	Interest in combining restoration effort with Marine Sanctuary	1	The creation of a marine sanctuary is outside the scope of work presented in the MSRP Phase 2 Final Restoration Plan and the limits of available funding.	[1; Sections 1.1, 2.1]

Project Funding

10	What is the cost of the project?	3	$6.5 million	
11	Who commissioned and paid for the studies?	7	The studies and restoration project have been/will be funded by NOAA MSRP, and not by Trump National Golf Course or Donald Trump himself. Additionally, research has been continuous for the last decade and funding for restoration work was secured nearly two decades prior to the existence of the Trump Administration.	
12	Does the project budget for possible adverse effects of construction efforts (e.g. hazardous spills)?	3	The issuance of a permit is contingent upon demonstrating the ability to assume liability for risks associated with the project. There have been concerns regarding the quarry rock used for reef construction and potential spills associated with oil and gas aboard marine vessels. The Project will adhere to California Department of Fish and Wildlife's (CDFW's) Material Specification Guidelines and employ Best Management Practices at every step of the construction process to prevent adverse effects. There are no additional hazardous chemicals or substances used in this project. Furthermore, all ocean-going vessels used for the Project would not transport such substances in quantities in excess of their operating requirements. Additionally, vessels would maintain emergency response and oil spill prevention plans in accordance with applicable regulations. Equipment and supplies to respond to a spill would also be onboard. Further, construction crews would be licensed, trained in oil spill response, and have a regular maintenance program to prevent a spill from an equipment malfunction.	
13	Would this project be under consideration if there were no Monsanto (sic) funds available?	45	This project would not be under consideration without the funds available through MSRP.	
14	There are better uses for MSRP funds	3, 11, 12, 15, 29, 32	Approximately 75% of the settlement funds have been used to address contaminated sediment, to reimburse past damage assessment costs, and to implement Phase I projects and studies. Under the terms of the settlement, the remainder (approximately $15 million) is to be used for additional natural resource restoration work including fishing and fish habitat restoration, Bald Eagle and Peregrine Falcon restoration, and seabird restoration. This Project addresses fish habitat restoration as part of the Phase II restoration activities.	[1; pg 1-6]

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
14a	….. specifically for disaster response	21, 36	Disaster response is not included as an objective in the settlement with Montrose Chemical Corporations.	
14b	….. specifically for DDT/PCB removal	45	Settlement funds specifically directed toward cleanup efforts are managed by the U.S. Environmental Protection Agency (EPA). According to the EPA's record of decision, the selected remedy for contaminated sediment is to place an isolation cap of clean sediment over contaminated sediments near the outfalls where the concentrations are highest.	[4; pg 2]
15	MSRP funds are not appropriate to use for this project since reef burial is not a function of Montrose pollutants	14, 18, 28, 31, 39	While Montrose Chemical Corporation's effluent is not responsible for the burial of these reefs, one stated purpose of the funds is to restore fishing losses to the region. This restoration project is one method for restoring loss habitat and creating a healthier ecosystem. One aspect of a healthier ecosystem is improved fishing opportunities; however, these reefs are not designed solely to benefit commercially or recreationally fished species.	

Restoration Reef Design

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
16	Project name and purpose are misleading as the project does not restore existing rocky reef	14	As stated in the EA, landslides deposited substantial terrestrial sediment into the project area, burying historic rocky reefs. This project seeks to restore that rocky reef habitat by constructing the restoration reef on top of those currently buried rocky areas.	[2; pg 4]
17	Requests reef design details and a detailed map of the restoration reef and project area	5, 34, 38	Reef design information and maps can be found in Reference #9.	Maps: [9; pgs 10, 13, 16, 21, 29, 30, 40, 41, 43] Design details: [9; pgs 27-37]
17a	….. and alternative designs	38	Alternative reef designs can be found in Reference #9.	[9; pgs 37-39]
18	What percentage of rocky reef in the Palos Verdes region will the restoration reef comprise?	14	There are approximately 3,182 acres of rocky reef at Palos Verdes Peninsula currently, including the buried/degraded reef areas. The restoration reef is designed to provide approximately 40 acres of buried/degraded rocky reef within the 69-acre site. Therefore, the restoration reef will comprise ~1.25% of rocky reef habitat at Palos Verdes Peninsula.	[2; pg 7], [10; pg 4]
19	Kelp surveys more recent than 2009 should be used to determine restoration reef location	34	The kelp cover data used during restoration reef design was an additive composite of all kelp cover from the 2008 and 2011 to 2014 seasons.	[9; pgs 10-13]
20	Is offshore transport of sediment a goal, and will it be successful?	14	Offshore transport of sediment is not a goal of this restoration reef.	
21	The Environmental Assessment states that the objective of the restoration reef is to create hard, rocky substrate upon which kelp will become established, while the MSRP Final Phase 2 Report states that kelp forest production is NOT a goal	14, 18, 28, 31, 39	Correct. The overall objective for building the restoration reef is to create the most productive habitat. While kelp growth will likely occur on the restoration reef, and production is partially a function of kelp growth, it is not the primary goal for building the reef.	[9; pg 31]
22	Lack of small-scale testing to determine effects	30	While no specific pilot study was conducted, many other reefs in the area have been monitored extensively. The effects of such a reef can't be "scaled-down" in a natural setting, as the size and extent of the reef complex is important for providing connectivity to existing natural reefs and to provide sufficient habitat to support self-sustaining populations of fish.	[9; pg 31]

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
23	Is this project considered to be experimental?	18, 28, 31, 39	This project is not considered to be experimental; however, experimental design was incorporated when designing the restoration reef. The restored reef is expected to provide statistically and biologically sound data on the effects of the project on the environment to potentially inform future restoration projects.	[9; pgs 27, 35]
24	Only one engineer named in the proposal	30	Section 10.1 provides the list of preparers of the EA; however, the personnel involved in the design of this project were comprised of a collaborative group of engineers, resource managers, and scientists.	[2; pgs 54-55]

Suggested Alternatives

25	Let nature run its course/do not interfere with nature	3, 12, 21, 45	The landslides resulting from human-caused environmental degradation has occurred to such an extent in this area that restoration of fish habitat in the form of artificial reefs would provide an ecosystem benefit. Due to the existing layer of sediment on top of former rocky reef habitat and the ongoing nature of the Portuguese Bend Landslide, the only way to restore rocky reef fish habitat in this area is to create a high-relief reef that will be resilient against the effects of sedimentation. Without the addition of high-relief rocky reefs, sediment would continue to cover and scour the relatively flat rocks that currently exist in the area, preventing natural recovery. By introducing rock that will remain exposed well above the sediment bed, natural processes of reef succession will result in colonization by a diverse and productive assemblage of marine organisms. The placement of the reef modules was designed so that sediment can move between the reef modules within a block through sand channels that are 10 to 20 m wide. This will help to prevent the buildup of sediment within reef blocks as sand is moved by wave action and longshore currents.	[2; pg 4], [9; pg 35]
26	Restoration reef should begin closer to Portuguese Point and overlap to redirect current and wave action away from the coastline in order to transport silt offshore and keep nearshore waters calm and clear while re-establishing tidepools	40	While creating a series of artificial barriers closer to the source of terrestrial input may promote offshore transport of silt and sediment while discouraging coastal erosion, this plan would: a) cause extensive damage to recreational (particularly surfing) opportunities along the shoreline; b) require reef heights that would pose a hazard to navigation; c) not be feasible within the proposed budget; and, d) not be within the scope of what MSRP Phase 2 Final Restoration Plan.	
27	Why not plant more kelp beds?	34	Kelp outplanting was considered but it was decided that direct outplanting would be unnecessary on the Palos Verdes Peninsula due to the high availability of natural kelp recruits in the region.	[1; pg A-21]
28	Sea otters should be relocated to the restoration reef to control sea urchin populations	40	This suggestion, while rooted in sound ecological theory, is not appropriate or necessary. Relocating sea otters is against two separate federal laws (Marine Mammal Protection Act and Endangered Species Act), and past efforts to do so by the U.S. Fish and Wildlife Service were deemed failures and were abandoned unofficially in 2003 and officially in 2012.	[1; pg A-14 to 15]

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]

Existing Artificial Reef Comparisons

29	Has an artificial reef been constructed near an ongoing landslide in the past?	18, 28, 31, 39	We are not aware of another artificial reef that has been implemented in the area of an active landslide; however, this reef was designed to be resilient against the ongoing sedimentation caused by the Portuguese Bend Landslide by maximizing the amount of vertical relief of the reef itself. Natural high-relief reef patches in the area have persisted and remain very productive because the rocks are well above the sediment. The project specifically incorporates sedimentation into the design. High-relief reefs are immediately upcoast and downcoast of the restoration area and are not being buried.	
30	No long-term studies of similar reefs	30	Artificial reefs are widely studied worldwide and have been shown to be highly productive fish habitat. Locally, there are numerous artificial reefs in similar water depths in Santa Monica Bay and on the San Pedro Shelf, and those with high relief components have been found to have high fish biomass. The components of this reef were designed to mimic the physical structure of a nearby natural reef with very high fish biomass. The researchers in this project have been continually studying artificial reefs in the region since 1974, the longest continual surveys of artificial reefs.	[5], [9; pgs 22-24]
31	Wheeler North Reef does not meet 5 of 14 critical issues	3	The Wheeler North Reef (WNR) at San Clemente has a different design and a different set of core objectives than this restoration reef. WNR was designed primarily to grow giant kelp and to maximize the acreage of new kelp habitat. This reef is specifically designed to provide productive fish and invertebrate habitat, and consists of a set of discrete high-relief modules.	[9; pgs 22-37]
32	No discussion/comparison to Belmont Pier Reef Restoration Project	32	The MSRP Trustee Council had previously investigated an artificial reef project located adjacent to the Belmont Pier. The purpose of this project was to change the species composition of the fish available to anglers from soft-bottom species that typically carry higher contaminant loads to rocky reef species that often carry lower contamination loads. As such, the purpose of the Belmont Pier project was not habitat restoration, but rather to create a more traditional fishing reef. The project was determined to be infeasible due to constraints associated with the lack of a local partner that would assume the long-term ownership of the reef and associated liability. In addition, at the time the Trustees evaluated the project, the City of Long Beach was in the process of evaluating the pier location. One option that was being considered was moving the pier to a new location, which would reduce or eliminate the intended value of the project to pier anglers. Neither of these issues are limiting factors for the current reef project. The intended goal of the current project is to restore fish habitat (independent of angling) and the Southern California Marine Science Institute (SCMI) will be the long-term lease holder for the project.	

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]

Likelihood and Measurement of Success

33	No evidence provided that the restoration reef would improve fish habitats	11, 30, 32	There is substantial evidence that artificial reefs, when correctly designed, can improve fish habitat. There is also a large amount of data suggesting that rocky reefs that are not covered in sediment are far more productive than rocky reefs that are covered in sediment. Additionally, this restoration reef design was modeled specifically after highly productive natural reefs immediately adjacent to the site. Conservatively ~6 tons (5,419 kg) of fish will be produced by this design.	[5], [9; pgs 22-26, 34]
34	No information given about likelihood of success or what metrics would define success/failure	14, 18, 28, 31, 32, 39	As this restoration reef is not being proposed as a mitigation for a specific set of lost services (unlike the WNR), there is no need to define specific goals for the project that would deem it a success or failure. However, post-construction monitoring will be conducted with side-scan sonar surveys to confirm the location of rock material, and diver surveys to assess the biological community and progress of habitat on the reef (see EA section 6.1.5). It is expected that at the very least more fish will utilize the restored habitat than currently do (which is nearly zero). Optimally, fish production and biomass values will be comparable or exceed other non-sediment-impacted reefs at Palos Verdes Peninsula.	[2; pg 41], [9; pgs 36-37, 41-45]
35	The restoration reef will be buried by continuous landslides and wave action	3, 11, 12, 14, 18, 25, 28, 31, 32, 36, 37, 39, 46	This reef was designed to be resilient against the ongoing sedimentation caused by the Portuguese Bend Landslide by maximizing the amount of vertical relief of the reef itself. Natural high-relief reef patches in the area have persisted and remain very productive because the rocks are well above the sediment. The project specifically incorporates sedimentation into the design.	[1; pg A-11], [9; pgs 25, 31, 33, 37]
35a	….. Will sink in to new fissures created by construction	34	The bedrock underlying the thin layer of sediment is solid rock, based on sub-bottom/echosounder profiles and corroborated by diver surveys. Neither the quarry rock nor the construction equipment has the capability to break through or create fissures in the bedrock layer.	[9; pgs 20-21, 40-41], [11], [12]

Restoration Reef Construction

36	Conflicting timelines for construction given	5, 7	The proposed project start date has been moved to summer/fall 2018.	
37	No testing of quarry rocks to determine chemical reaction with ocean, decomposition rates, or chance of movement	30	The quarry rocks used to construct the reefs will be compliant with the guidelines set forth by the CDFW, which state that: (1) materials shall be clean and free of any contaminants, especially those that could dissolve in seawater, (2) materials shall be free of foreign materials, (3) specific gravity must be greater than 2.2, and (4) rocks must be durable enough to remain unchanged after 30 years of submersion in seawater. This is standard for reefing and breakwater projects in California.	
38	Reports states that no permanent structures will be constructed. Is the reef not permanent?	3, 14	This statement refers to the visual and construction equipment aspect of the project, not the reef itself.	[2; pg 44]
39	Air pollution concerns	7, 27, 34	According to an analysis of the project using assumptions based on worst-case conditions, none of the construction-related emissions will be above the daily or quarterly emission thresholds for CEQA analysis established by the South Coast Air Quality Management District.	[6]

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
40	Noise level concerns	7, 27, 34	Noise levels resulting from construction at sensitive noise receptors would range from 38 to 58 decibels (A-weighted; dBA), which are below the maximum acceptable noise levels outlined in the regulatory framework of the Rancho Palos Verdes General Plan, the City of Los Angeles General Plan, and the Los Angeles County General Plan. The project will raise ambient noise levels between 0 and 1.5 dBA, well below the threshold for creating a physical or psychological effect from construction noise. Furthermore, all construction-related activities will be conducted between the hours of 7 a.m. and 7 p.m. to remain compliant with the regulatory framework.	[7]
Effects on Local Businesses and Vessel Traffic				
41	What are the effects on vessels and vessel traffic?	7	The impacts on large vessel traffic will be negligible. The reef site is 0.3 mile from the shoreline in depths less than 66 feet. The shipping lane is located several miles offshore in much deeper water. For smaller commercial and recreational fishing and diving vessels, the reefs are situated deep enough to be of no concern for small boaters as the shallowest reef component will be 40 feet below the surface at mean lower low water. Once completed, the restoration reef will be surveyed and charted in conjunction with NOAA's Office of Coast Survey.	[13]
42	Potential damage to business at Trump National Golf Course	7, 27, 34	As provided in Section 9.4 (page 53) of the EA, no permanent structures will be visible following the end of the construction period. Also see responses to Comments 38-40.	
Surfing, Waves, Geological, and Coastline Impacts				
43	Requests a map of faults, fissures, and slides both onshore and underwater	34	See Reference 12.	[12; pgs 1-14]
44	Unknown impacts of restoration reef on landslide areas and coastline	3, 4, 13, 18, 21, 22, 23, 28, 31, 33, 34, 35, 39, 41, 43	There is no reason to expect that the placement of an artificial reef 0.3 miles offshore will affect the rate of erosion of the toe of the landslide. The rate of the landslide itself is controlled by terrestrial processes and will not be affected by the restoration reef.	[3]
44a	….. How will damage to homes and roads be mitigated?	34	Please see response to Comment 44.	
45	Previous ideas about placing a breakwall at Portuguese Bend were abandoned; reasoning should be explored	3	Assuming the Comment is referring to the 2000 proposal to build a sediment containment dike offshore of Portuguese Bend Landslide, the project was not recommended for authorization for numerous reasons, the most prominent being concerns about the ability of the proposed structure to contain sediments from the landslide. That project was deemed unfeasible. That project was also outside of the proposed study and restoration area and was intended to stop flow of sediment downcoast and help stabilize the toe of the landslide. This restoration project does not seek to do either of those things.	[14]

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
46	Restoration reef may damage surfing conditions	3, 6, 10, 11, 12, 14, 17, 21, 23, 25, 26, 29, 38, 43	The nearest surf breaks to the project site are The Shack, K & G Point, Bee Aye Point, and Japan Cove. The Shack is most ridable with west swell that will not pass over the restoration reefs. K & G, Bee Aye, and Japan Cove surf breaks are all best with swells from the south or south-southeast (SSE). These swells will not pass over the restoration reef prior to reaching Japan Cove. South and SSE swells will pass over the restoration reef before reaching K & G and Bee Aye; however, the water depth between the top of the restoration reef and the water's surface is at least 40 feet. Typical surfable waves on our coast will not break until a bottom depth of < 20 feet is reached. Wave conditions along the Rancho Palos Verdes coastline are controlled by shallow natural reefs that lie inshore of the project site in water depths of approximately 13 to 20 feet. Additionally, since the reef modules are comprised of narrow sets of individual rock piles rather than a single large obstacle set parallel to shore, most of the wave energy will pass well over the top of the reef and through the channels between reef modules. The naturally existing reef that these restoration reef modules are modeled after lies directly in the path of the Japan Cove surf break and clearly does not cause any harm to surfing conditions.	Figure 1, [15; pgs 6-7], [Cleary and Stern, 1963. "Surfing Guide to Southern California"], [18; pg 1 – 3]
46a	….. provide map of surf breaks in relation to proposed restoration reef	38	See References 15 and 18.	[15; pg 7], [18; pg 1]
47	No models of changes to tidal flow	30	Tidal flow will not be influenced by the restoration reef.	
48	Study relating increased kelp on surf and shore conditions is from San Clemente and is not applicable to Palos Verdes	3, 14, 26, 38	We believe that this study is indeed appropriate. The reef referenced in the study had no measurable influence on long period swells, yet it was placed in shallower water than the proposed Palos Verdes Reef. The physics of wave shoaling and breaking are consistent between the two locations, and there is no reason to believe that this deeper reef will have any additional effect on long period waves.	[17; pg 4.3-4 – 4.3-5]
49	Should include a surfing wave enhancement element in the design	16	A surfing wave enhancement is outside the scope of work presented in the MSRP Phase 2 Final Restoration Plan and the limits of available funding.	[1; Sections 1.1, 2.1]

Ecological Concerns: Kelp Beds and Rocky Reefs

50	Stated purpose of the restoration reef is to restore kelp beds, but kelp beds are healthy at present	7	Although one of the parameters for siting the restoration reef included suitable depths for kelp forest establishment, and the restoration reef would likely provide substrate for kelp, it is not designed to restore kelp. There is a different project that includes kelp restoration, which is also a part of MSRP, but kelp restoration is not a key purpose of the restoration reef project.	[9; pg 31]
51	Are the kelp beds in bad shape?	7	No. Since the 1970s, kelp beds along Palos Verdes Peninsula have been increasing in size and persistence as a product of improved wastewater treatment and other MSRP restoration efforts.	
52	Why is there no kelp in the circular area towards the east, nearshore?	34	This area is mostly a sand/mud bottom that is not suitable for kelp growth; it is directly below a natural gully where runoff from the peninsula flows from north of Palos Verdes Drive South (beginning just south of Seaclaire Drive) into the ocean where it is deposited onto the ocean floor.	

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
53	No need for more rocky reef or kelp	12	Significant amounts of reef and kelp habitats have been lost on the Palos Verdes Peninsula since the mid-20th century due to pollution and several landslides including the Portuguese Bend Landslide beginning in 1956.	[1; pg 5.14]
54	East Area would benefit more from increased kelp because there is less kelp there than in the West Area.	26	It's true that the East Area currently has less kelp than the West Area. However, the West Area was selected because the fine-grained sediments are thinner within the depths most suitable for reef construction. The relative absence of fine-grain sediments means the quarry rock would be less likely to sink or be covered by sediments, which would hinder kelp from becoming established.	[2; pg 7]
55	Why would hard-bottom associated fauna inhabit the new reef when they don't inhabit current/adjacent hard-bottom habitat?	3	The current/adjacent habitat is heavily degraded by sedimentation and scouring, whereas restoration reef habitat would provide more protected substrate for flora and fauna that are susceptible to these effects.	[9; 13-19]
56	Not enough increase in kelp bed/rocky reef acreage for project cost	3, 14	Based upon the analyses of multiple reef designs, this is the most cost-effective reef design in terms of overall reef production.	
57	Kelp forests will not grow on restoration reef due to presence of sea urchins at the site.	11	While kelp growth will likely occur on the restoration reef, it is not the purpose of building the reef. Regarding sea urchin grazing preventing growth of kelp, the urchins on adjacent/current reefs are in low enough densities not to create barrens due to overgrazing. Additionally, the depths of the restoration reefs are generally below the preferred depth for the urchins (purple sea urchins, *Strongylocentrotus purpuratus*) that are mostly responsible for creating urchin barrens in southern California.	[9; pg 31], [16]

Ecological Concerns: Physical Damage from Construction

58	Kelp/rocky reef will be damaged as a result of the construction process	22, 25, 26	Reef construction has the potential to damage existing benthic communities, but the reef site consists primarily of degraded sandy-bottom and degraded/buried hard substrate bottom habitat. Construction will implement a proactive anchoring plan to minimize impacts by avoiding hard substrate and anchor drag.	[2; pg 36-37]
58a	….. How will damage to adjacent/existing reefs from restoration reef construction be mitigated?	14, 18, 28, 31, 39	See response to Comment 58.	
59	Soft bottom marine life and habitat will be destroyed as a result of the construction process	3	The soft-bottom marine life that are most likely to be affected by construction of the restoration reef are common throughout the Southern California Bight, though not dense enough to be harmed in great numbers during construction. Additionally, soft-bottom habitat is far more common and of far less ecological value than hard-bottom habitat.	[2; pg 37]
60	Are endangered species impacted?	7	No endangered species are impacted.	[2; pgs 13, 19, 22, 16]

Ecological Concerns: DDTs/PCBs and Human Health

61	Diversion of sediments for Portuguese Bend Landslide would prevent further burial of DDTs/PCBs	24	Offshore transport of sediment is not a goal of this restoration reef, nor is it expected to be a major function of this project. However, the movement of sediment from Portuguese Bend offshore to bury dichlorodiphenyltrichloroethane/polychlorinated biphenyl (DDTs/PCBs) will not be affected by this project.	

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
62	Construction will disturb sediment and release DDT/PCBs	10, 14, 17, 18, 21, 23, 25, 28, 29, 31, 32, 34, 39, 43, 46	Resuspension of contaminated sediment was a major consideration when evaluating alternatives for this project. The current understanding is that any additional contamination from re-suspended sediment would be extremely minor for two important reasons. First, the reef will be constructed on a shallow layer of sand that is covering a historic low-relief reef. Thus, there is very little sediment that could be disturbed. Second, and perhaps more important, is that the actual concentrations of DDT compounds and PCBs in the project area are very low when compared with the sediments farther offshore and closer to the White's Point outfall, and comparable to other nearshore areas in southern California. The amount of DDT in the sediment is at the ambient levels consistent with the rest of the nearshore habitats in the Southern California Bight, and reef construction will not expose any buried pollutants that are not currently available to the ecosystem.	[1; pg A-12], [8]
62a	….. How will recontamination issues be addressed?	32	See response to Comment 62.	
63	DDT/PCB concentrations have not decreased in fishes in spite of decreases in sediments; should not be encouraging fishing in areas with DDT/PCB contaminated fishes	32	DDT concentrations in the muscle tissue of white croaker (*Genyonemus lineatus*) have been monitored since the 1980s. The total DDT found in white croaker muscle tissue has shown a sharp decline since the year 2000. Furthermore, total DDT in the muscle tissue was found to be significantly lower in the 2000s compared to the 1990s, and continues to decline in the 2010s. However, white croaker are a soft-sediment associated species and would not be a target species for people fishing on the restoration reef. Rocky-reef associated species such as kelp bass (*Paralabrax clathratus*) and black perch (*Embiotica jacksoni*) are less limited by fish consumption advisories than white croaker. Furthermore, while the goal of this project is not to enhance fishing opportunities, there is no legal recourse to prevent fishing on the restored reef or the natural reefs in the area. The Institutional Controls portion of the MSRP Phase 2 seeks to provide the public with the necessary information about contaminants in order for them to make healthy choices for themselves and their families.	[1; pg A-10], [8]
63a	….. Shore-based hook and line anglers are disproportionately represented by minorities, therefore exposing more minorities to DDT/PCB contaminated fishes; this is contrary to the CSLC's policy on Environmental Justice	32	The proposed restoration reef is approximately 600 m offshore, beyond kelp beds. The restoration reef is not an area accessible to shore-based anglers; therefore, there would be no risk to shore-based anglers.	[1; pg A-10], [8], [9; pgs 10, 13, 16, 21, 29, 30, 40, 41, 43]
64	How will injuries to divers by moving rocks from the restoration reefs be prevented?	34	Storms, swell, and surge will undoubtedly jostle the piles to some degree soon after construction. Rocks will settle into a stable position far prior to harvestable species settling in/around the restoration reefs. This construct will be no different that breakwaters, jetties, and other artificial reefs in that while divers can and do eventually explore and harvest from them, they must do so at their own risk. We know of no reported injuries to divers associated with such structures.	

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]

Ecological Concerns: Marine Mammals

65	Is it feasible that whales could come inshore as far as the proposed restoration reef?	38	While whales, particularly gray whales (*Eschrichtius robustus*), could feasibly come inshore as far as the proposed restoration reef, the reef was designed to mimic highly productive natural reefs nearby. Gray whales generally do not forage during their migration, but they have been observed skimming kelp beds for food and utilizing kelp forest for escape cover. These areas are believed to be particularly important to cow-calf pairs in the northern migration during late winter and spring. Accordingly, the presence of a kelp-covered reef could have a beneficial effect upon gray whales. During the time frame of construction (May-September), there are three species of migratory whales that may be found in the project area. These include: (1) blue whales, (2) fin whales, and (3) humpback whales. However, these whales are generally found farther from shore than where project construction will occur and are adept at avoidance. The project is being planned to avoid the gray whale migration period.	
65a	….. if so, marine wildlife monitoring during construction of the restoration reef should be incorporated into the project	38	During the construction phase of the project, a trained and qualified marine mammal observer will be placed at the construction site for the purpose of monitoring marine mammals and other sensitive marine species as set forth in the guidelines of the National Oceanic and Atmospheric Administration's West Coast Region. If sensitive marine wildlife is observed within the safety zone radius specified in the permit, survey operations will cease until the animal(s) is gone.	[2; pg 41]
66	Restoration reef will not increase marine mammal life	33	This is not a goal of the restoration reef.	

Unidentified Concerns

67	Unidentified safety concerns	27	Safety is of utmost importance. All applicable laws, regulations, and guidelines will be strictly adhered to with regard to safety of workers, the marine environment, and the public.	
68	Not enough attention given to "unavoidable environmental effects"	3	The section of the EA (Chapter 7) describes the effects that will undoubtedly occur as a result of the construction process. It is not intended to describe any potential negative effects the reef itself may have on the environment; this information is available in Chapter 6.	[2; pgs 36-48, pg 49]
69	Project risks outweigh the benefits	4, 8, 10, 15, 22	Large construction projects such as this do carry risks to the environment and to people. However, many measures have been taken to minimize risks to the seafloor during construction, eliminating any increase in public exposure to toxic pollutants, sedimentation, impacts to recreation, air quality, noise, and many more. The benefits include an increase in productive habitat for fish and other marine species in a highly impacted section of the southern California coast.	[2]

Local, County, State, and Federal Agency Requests and Recommendations

70	Request placing restoration reef >100 m of Sanitation Districts' light energy monitoring station	9	We will attempt to adjust the restoration project to accommodate this request in the final design. We do not anticipate that the final design will affect light levels and will work with LACSD to accommodate their monitoring program.	

Comment No.	Summarized Question, Comment, or Concern	Contact Nos.	Response to Comment or Concern	References [#, pgs]
71	Request advance notice and communication during construction period to avoid potential conflicts between NPDES permit-required sampling efforts	9	Notice will be given to Los Angeles County Sanitation District and all other affected parties as far in advance as possible.	
72	Include California Coastal Act as an applicable law in Section 4 and revise the language in Section 4.5 to reflect the change	38	The California Coastal Act is discussed in Section 5.5.4.1 of the EA.	[2; pg 29]

Table 3. References and associated “References No.” given in Table 2.

Reference No.	Reference
1	Montrose Settlements Restoration Program. 2012. Final Phase 2 Restoration Plan and Environmental Assessment/Initial Study. Report of the Montrose Settlements Restoration Program, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, National Park Service, California Department of Fish and Game, California Department of Parks and Recreation, and California State Lands Commission.
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7	Coastal Environments, Inc. 2015. Palos Verdes Reef Restoration Project: Noise. Prepared for Vantuna Research Group.
8	Vantuna Research Group. 2017. DDT Concentrations at the Bunker Point Reef Restoration Project Study Area.
9	Vantuna Research Group. 2016. Bunker Point Reef Restoration Project: Criteria, Design, and Monitoring. Prepared for NOAA/MSRP.
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15	Coastal Environments, Inc. 2015. Palos Verdes Reef Restoration Project: Recreation. Prepared for Vantuna Research Group.
16	Claisse, J.T., J.P. Williams, T. Ford, D.J. Pondella II, B. Meux, and L. Protopapadakis. 2013. Kelp forest habitat restoration has the potential to increase sea urchin gonad biomass. Ecosphere 4(3):38
17	Resource Insights, 1999. Final Program Environmental Impact Report for the Construction and Management of an Artificial Reef in the Pacific Ocean Near San Clemente, California. Prepared for California State Lands Commission.
18	Vantuna Research Group. 2017. Surfing Opportunities and the Bunker Point Reef Restoration Project.

APPENDIX D2

WHITE PAPER: DDT CONCENTRATIONS AT THE BUNKER POINT RESTORATION REEF PROJECT STUDY AREA

PREPARED BY THE VANTUNA RESEARCH GROUP AT OCCIDENTAL COLLEGE IN COORDINATION WITH THE MONTROSE SETTLEMENTS RESTORATION PROGRAM

DDT Concentrations at the Bunker Point Reef Restoration Project Study Area

Summary

- The main Palos Verdes Shelf contamination site lies offshore of the proposed reef restoration site and the most recent surveys have shown a significant decline of DDTs on the entire Palos Verdes Shelf.
- Placement of restoration reef materials at the proposed Bunker Point site will not unbury latent DDTs on the Palos Verdes Shelf.
- DDTs in the project site are 5-50x lower than the offshore contaminated site.
- DDTs in White Croaker tissue has declined significantly over the last decade.
- DDTs in project site are comparable to those found throughout the Southern California Bight in shallow (< 30 m) soft bottom offshore habitats.

From the 1940s to the 1970s, industries in the Los Angeles County area discharged DDT into the ocean waters off the Southern California coast. Most of the DDT that was released was produced by the Montrose Chemical Corporation (MCC), a manufacturing plant located in Torrance, California. Waste from MCC was pumped into the Los Angeles County Sanitation District's (LACSD) sewer collection system, where treatment methods at the time were unable to capture DDT prior to their discharge via ocean outfall pipes. The LACSD's outfall pipes emptied into the Pacific Ocean off Whites Point on the Palos Verdes Shelf. Additional DDT-contaminated waste was dumped by Montrose off barges into the ocean in the San Pedro Basin near Catalina Island (Coastal Environments 2016).

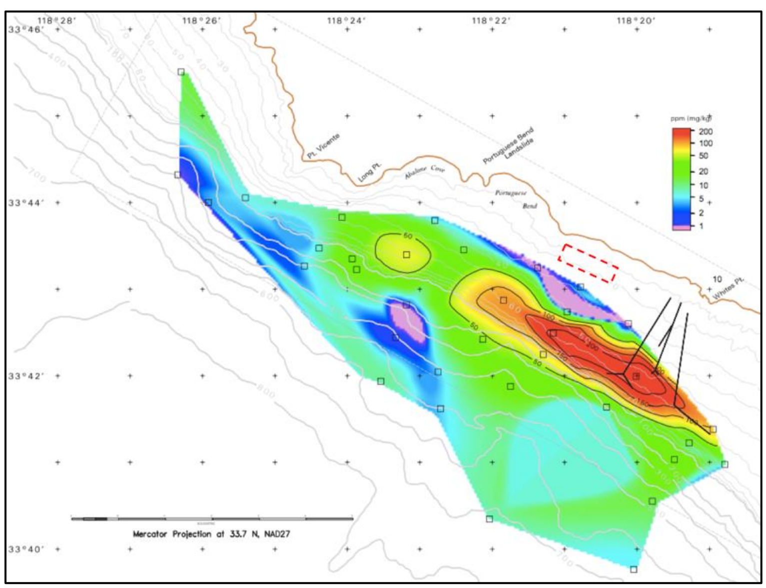

Figure 1. Peak Total DDT at the Palos Verdes Shelf Superfund Site, including the study area (red dashed outline). Figure reproduced and adapted from Lee (1994).

Environmental Protection Agency (EPA) funded studies in 2009 demonstrated that concentrations of contaminants of concerns (COCs) have significantly decreased from a peak level of contamination in 1992 (**Figure 1**, **Figure 2**), and it is likely that concentrations of DDTs (DDT, DDE and DDD) on the Palos Verdes Shelf will continue to decrease in the future (ITSI Gilbane Company & CDM Smith 2014). To further examine the potential contamination of sediment in the proposed restoration site, eight sediment samples were collected from the project area in 2016 by the Vantuna

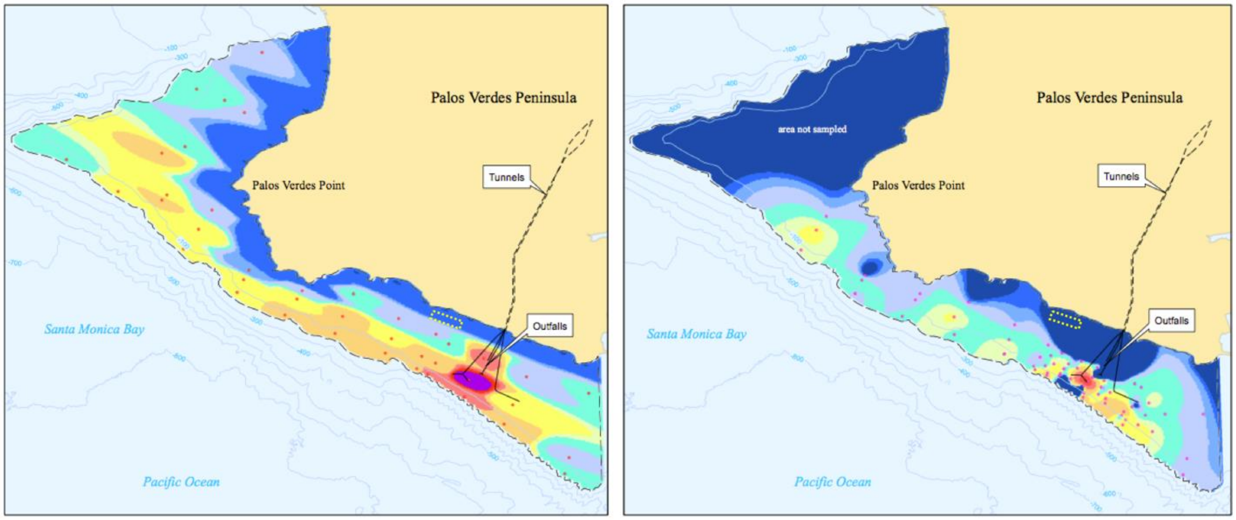

Figure 2. *Comparison of DDT distribution in 2002/2004 and 2009 with respect to the study area (yellow dashed outlines). Warmer colors indicate higher concentrations of DDTs. Figure reproduced and adapted from ITSI Gilbane Company & CDM Smith (2014).*

Research Group, tested for DDT and its isomers (DDE and DDD), and compared to historic levels of these contaminants from nearby survey stations (**Figure 3**, **Table 1**). In 2016, DDT was only observed at Station 1, with a concentration of 10.5 µg/kg DW (equivalent to ppb). Samples from all stations contained DDE with concentrations varying from 5.78 to 30.54 µg/kg DW, indicating that DDT was present it had deteriorated to DDE, and the area is recovering from the presence of DDT. This finding is consistent with the view that there have been no additional inputs of DDT at the project site. Of note, DDT and DDE concentrations are 5 to 50 times lower (respectively) than in previous surveys at nearby locations (**Figure 3**, **Table 1**). DDD was not detected in any sample (Coastal Environments 2016).

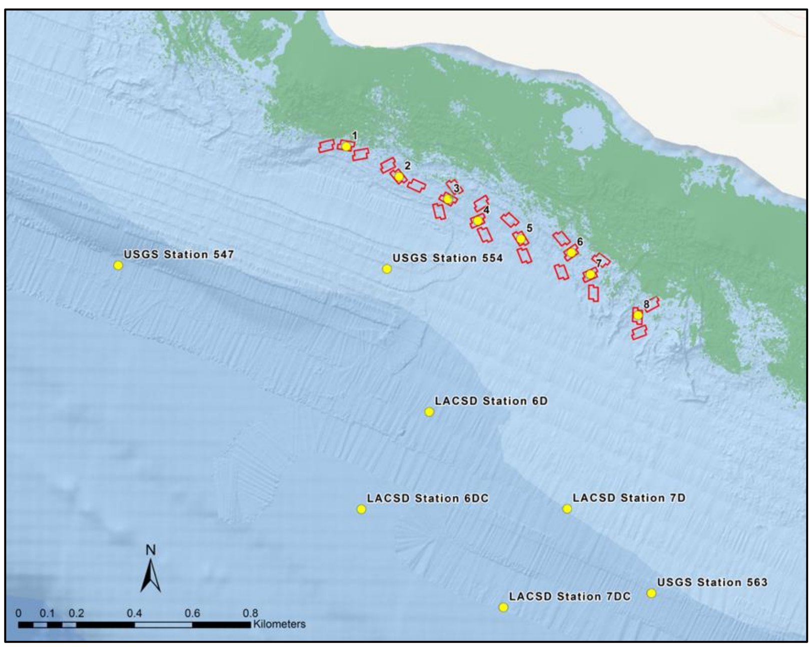

Figure 3. *Map of study area with 2016 sediment chemistry stations (1-8) and stations surveyed by LACSD and USGS from 1992 to 2009.*

Table 1. *DDD, DDE, DDT, and Total DDTs concentrations in µg/kg DW ± 95% confidence intervals (when available) from sampling stations nearest to the study area from 1992 to 2009, from Bight Regional Monitoring stations at depths of < 30m ("Inner Shelf"), plus stations (1-8) inside the study area in 2016. Total DDTs includes all isomers of DDD, DDE, and DDT. "–" indicates analyte was not tested for at that station during that year. Data from Schiff and Gossett (1998), Noblet et al. (2002), Schiff et al. (2006), Schiff et al. (2011), CH2M Hill (2007), Coastal Environments (2016), ITSI Gilbane Company & CDM Smith (2014), and LACSD (2016).*

		DDD (µg/kg)		DDE (µg/kg)		DDT (µg/kg)		Total DDTs (µg/kg)										
Depth	**Station**	**2009**	**2016**	**2009**	**2016**	**2009**	**2016**	**1992**	**1998**	**2002**	**2003**	**2004**	**2008**	**2009**	**2013**	**2014**	**2015**	**2016**
15-20 m	1	—	ND	—	6.36	—	10.5	—	—	—	—	—	—	—	—	—	—	16.86
	2	—	ND	—	7.8	—	ND	—	—	—	—	—	—	—	—	—	—	7.8
	3	—	ND	—	13.2	—	ND	—	—	—	—	—	—	—	—	—	—	13.2
	4	—	ND	—	9.24	—	ND	—	—	—	—	—	—	—	—	—	—	9.24
	5	—	ND	—	30.54	—	ND	—	—	—	—	—	—	—	—	—	—	30.54
	6	—	ND	—	8.25	—	ND	—	—	—	—	—	—	—	—	—	—	8.25
	7	—	ND	—	11.8	—	ND	—	—	—	—	—	—	—	—	—	—	11.8
	8	—	ND	—	22.5	—	ND	—	—	—	—	—	—	—	—	—	—	22.5
Bight Inner Shelf (< 30m)		—	—	—	—	—	—	—	33.5 ±33.3	—	2.3 ±0.4	—	20 ±22	—	12 ±15	—	—	—
30 m	USGS Station 547	—	—	—	—	—	—	655	—	—	—	—	—	—	—	—	—	—
	USGS Station 554	—	—	—	—	—	—	980	—	—	—	—	—	—	—	—	—	—
	USGS Station 563	—	—	—	—	—	—	457	—	—	—	—	—	—	—	—	—	—
	LACSD Station 6D	—	—	—	—	—	—	800	—	570	—	400	—	—	—	220	210	—
	LACSD Station 7D	—	—	—	—	—	—	560	—	630	—	450	—	—	—	320	250	—
40 m	LACSD Station 6DC	38.2	—	361.1	—	65.3	—	—	—	—	—	—	—	464.5	—	—	—	—
	LACSD Station 7DC	28.8	—	217.4	—	54.8	—	—	—	—	—	—	—	301.0	—	—	—	—
	Outfall Station 09	115.5	—	360.6	—	13.4	—	—	—	—	—	—	—	489.3	—	—	—	—

Effects level benchmarks from the NOAA Office of Response and Restoration (Buchman 2008) for all DDT and DDT isomers are presented in **Table 2**. These values generally range from more conservative to less conservative: threshold effects level (TEL), effects range-low (ERL), probable effects level (PEL), effects range median (ERM), and apparent effects threshold (AET). Higher thresholds (e.g., PEL, ERM, AET) identify pollutant concentrations above which effects can be expected and may be approaching toxic levels (Buchman 2008, Hou et al. 2009). DDT concentration at Station 1 was above all benchmarks except for AET, suggesting DDT at that location may have effects on various benthic infauna and epifauna. DDE benchmarks are more complex and variable, however all samples tested below the PEL, all but one (Station 5) tested below the ERM, yet only three stations (1, 2, 6) tested below the AET. These results suggest the potential for effects on benthic infauna and epifauna, but with lower certainty and probability.

Table 2. *NOAA effects level benchmarks for DDD, DDE, DDT, and Total DDTs (in µg/kg DW). Total DDTs includes all isomers of DDD, DDE, and DDT. From Buchman (2008).*

Benchmarks	**DDD**	**DDE**	**DDT**	**Total DDTs**
TEL: Threshold Effects Levels	1.22	2.07	1.19	3.89
ERL: Effects Range-Low	2	2.2	1	1.58
PEL: Probably Effects Level	7.81	374	4.77	51.7
ERM: Effects Range-Median	20	27	7	46.1
AET: Apparent Effects Threshold	16	9	12	11

DDT has degraded slowly in the environment and have bioaccumulated in animals that are in higher trophic levels. The Monitoring and Reporting Program (MRP) for the Joint Water Pollution Control Plant (JWPCP) National Pollution Discharge Elimination System (NPDES) permit requires the Los Angeles County Sanitation Districts (LACSD) participate in a bioaccumulation trends survey. This survey is conducted annually and builds upon sampling performed by NOAA (Mearns et al. 1991) and MBC Applied Environmental Sciences (MBC 1994) in the 1980s and 1990s.

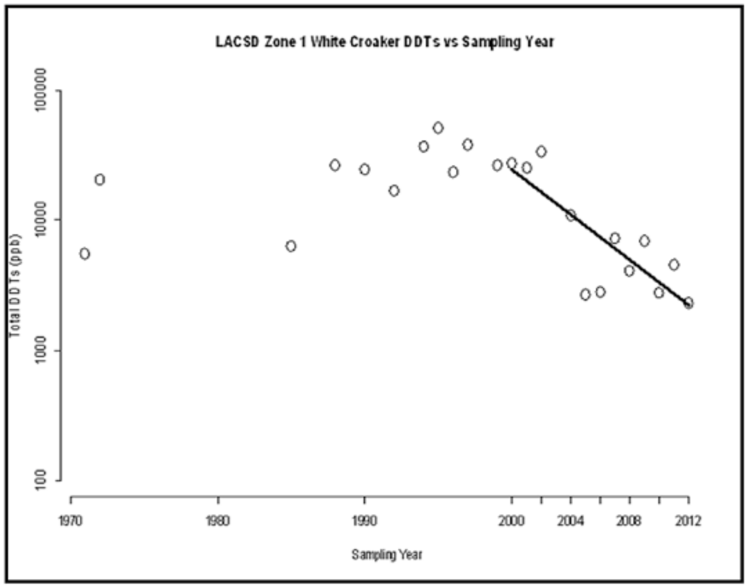

Figure 4. *Concentration of Total DDTs (ppb) in White Croaker* (Genyonemus lineatus*) muscle tissue from the study area, 1971-2012. Figure reproduced from Coastal Environments (2016); data from Mearns et al. (1991), MBC (1994), and LACSD (2016).*

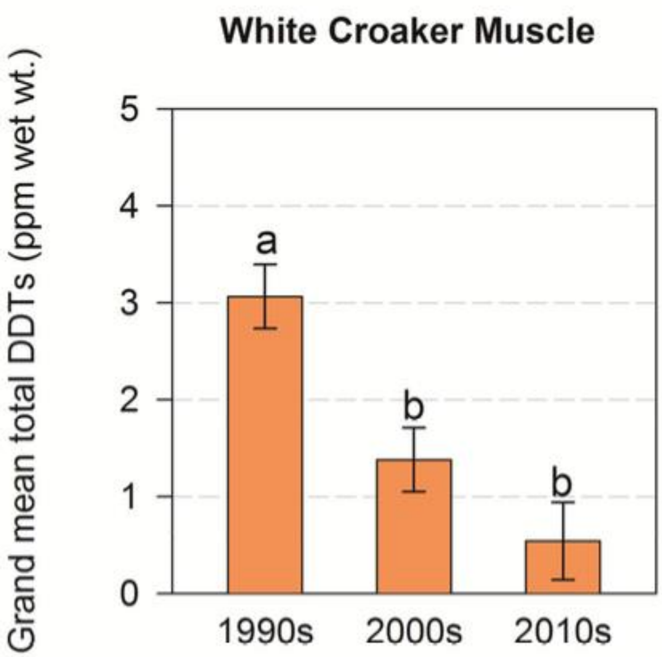

Figure 5. *Mean total of DDTs found in White Croaker* (Genyonemus lineatus*) muscle tissue at Palos Verdes Peninsula by decade. Letters indicate significant differences in concentration of DDTs. Figure reproduced from LACSD (2016).*

White Croaker (*Genyonemus lineatus*) are not only an important recreational and commercial fisheries species in the Southern California Bight, but they are also considered a sentinel species for tissue contamination. This soft-bottom associated species becomes highly contaminated as they feed on benthic organisms from contaminated sediment. However, temporal trends at LACSD Zone 1 (the area near the outfalls and encompassing the study site) show a sharp decline in Total DDT found in White Croaker muscle tissue since the turn of the century (**Figure 4**). Furthermore, Total DDT in White Croaker muscle tissue was found to be significantly lower in the 2000s compared to the 1990s, and continues to decline in the 2010s (**Figure 5**; LACSD 2016).

Regional sampling of nearshore (< 30m) areas throughout the Southern California Bight (**Figure 6**) has historically shown far lower levels of Total DDTs than in deeper areas of the shelf (Schiff and Gossett 1998, Noblet et al. 2002, Schiff et al. 2006, Schiff et al. 2011; Table 1). The 2016 samples are consistent with the 2008 (20 ±22 ug/kg) and 2013 (12 ±15 ug/kg) for the shallow water (<30 m) soft bottom habitats within the bight. The proposed subtidal rocky-reef habitats lie between 10m and 20m isobaths, far inshore of the historically highly contaminated sediments which lay beyond the 30m isobath (**Figures 1-3**, **Table 1**).

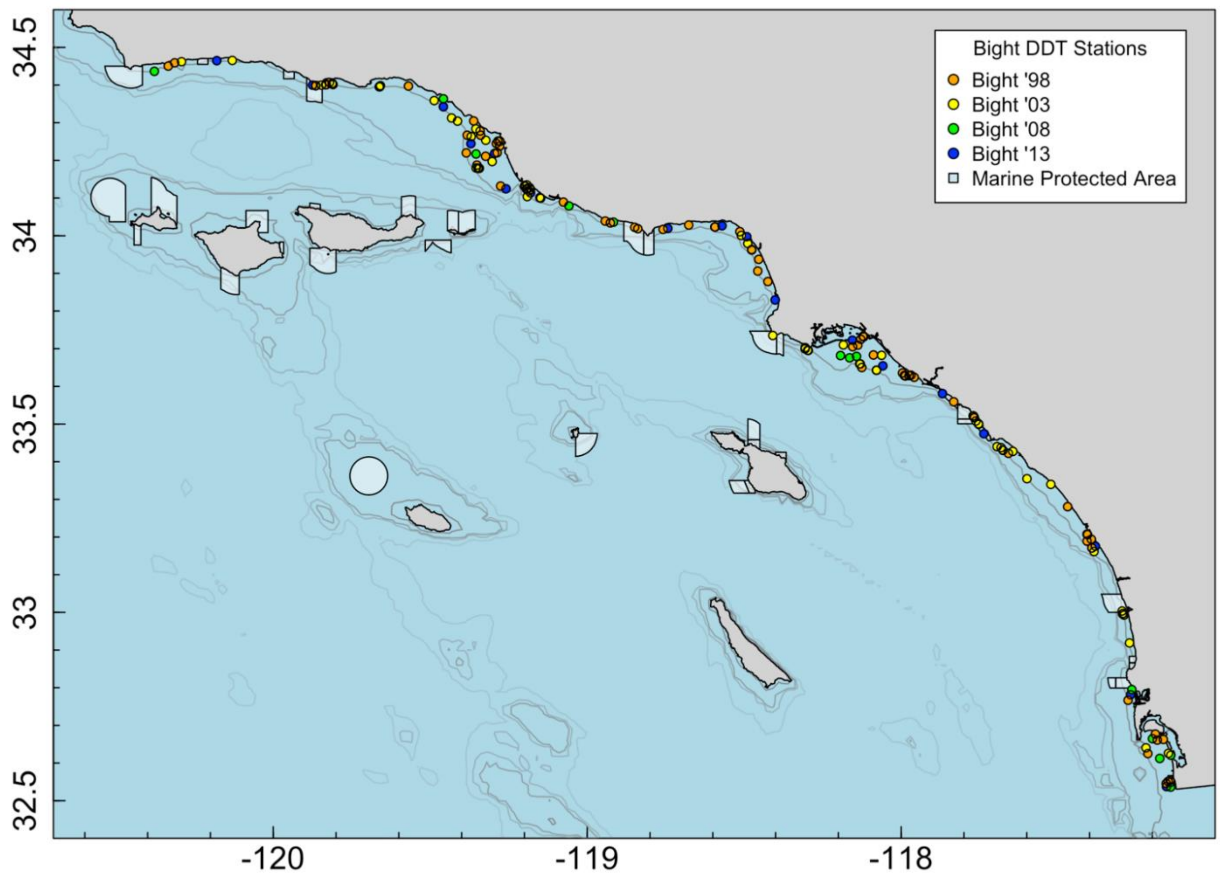

Figure 6. *Map of the Southern California Bight with locations of Bightwide Regional Survey (from 1998-2013) stations where DDT compounds were sampled for and quantified.*

Additionally, construction of a rocky reef is designed to alter the fish communities in the study area. The highly-contaminated soft-bottom associated fishes typically do not inhabit rocky-reef habitats (Allen 1999), therefore a primary benefit of placing rocky reefs even in contaminated soft-bottom habitats would be to displace soft-bottom associated species with midwater and rocky-reef associated species that do not typically feed on benthic organisms from contaminated sediment (MSRP 2005). Not only will this increase production of fishes whose tissues typically have lower concentrations of DDT (Dixon and Schroeter 1998), but organisms that prey on fishes in the study area will also be exposed to reduced levels of DDT, including recreational anglers (MSRP 2005).

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APPENDIX D3

WHITE PAPER: SURFING OPPORTUNITIES AND THE BUNKER POINT REEF RESTORATION PROJECT

PREPARED BY THE VANTUNA RESEARCH GROUP AT OCCIDENTAL COLLEGE
IN COORDINATION WITH THE
MONTROSE SETTLEMENTS RESTORATION PROGRAM

Surfing Opportunities and the Bunker Point Reef Restoration Project

Summary

- High vertical relief is a critical requirement for restoring sediment-impacted rocky-reef habitat while avoiding further sedimentation impacts.
- Wave conditions along the Rancho Palos Verdes coastline are controlled by shallow, high relief natural reefs inshore of the project site.
- The restoration reef will not affect wave conditions at adjacent surf spots, even during 100-year-wave events.
- The restoration reef will not affect sediment transport and deposition patterns that could affect wave conditions.

The proposed restoration reef modules are modeled after a nearby, natural, high-relief reef (KOU Rock; **Figure 1**) that does not suffer the ill-effects of sedimentation that the low-relief reefs in the adjacent 69-acre restoration area do. High vertical relief is a critical requirement for restoring sediment-impacted rocky-reef habitat while avoiding further sedimentation impacts. Local residents have expressed concern that added rocky reef structure represents a potential barrier to wave action at local surf breaks inshore of the restoration area and will negatively affect surfing conditions. These concerns have been addressed by previous studies at other locations in the Southern California Bight (SCB) and are further addressed specific to the southern Palos Verdes Peninsula shoreline herein.

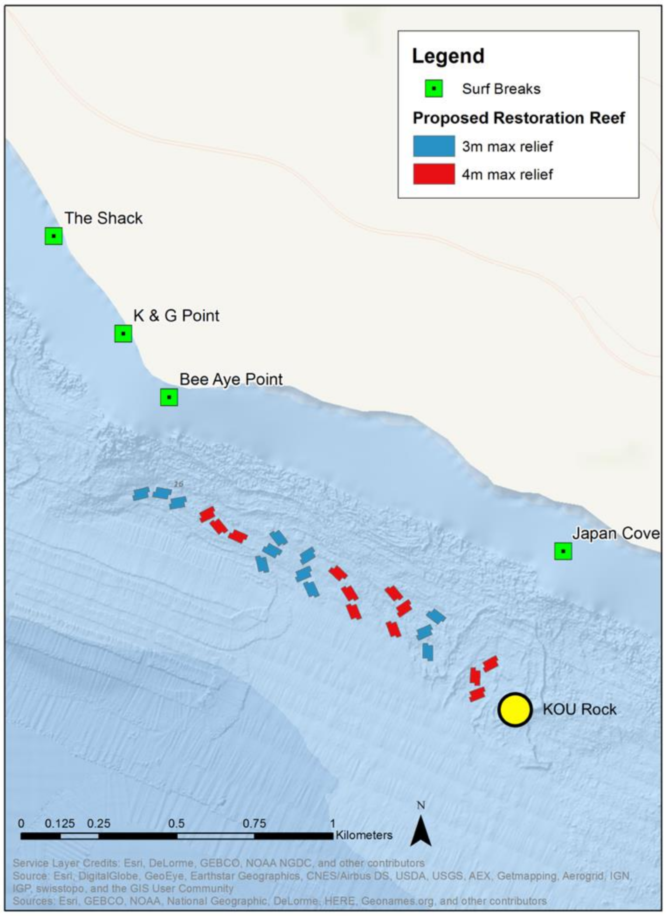

Figure 1. *Location and position of KOU Rock, the proposed restoration reef modules, and surf breaks along the Palos Verdes Peninsula.*

As a result of shadowing from the southern Channel Islands, Palos Verdes Peninsula has a relatively mild wave climate compared to other areas in the SCB. Most of the wind waves that reach the SCB originate in the north Pacific Ocean near the Gulf of Alaska and are diffracted by Point Conception, causing the swell to arrive at a more northwesterly angle. Northwest swell energy is both diffracted and attenuated due to the Channel Islands' creation of a wave shadow zone on the leeward side of the islands. Both south and west swells can strike the SCB shoreline more directly than the more common northwest swell (Coastal Environments, 2015). The nearest surf breaks to the restoration site are The Shack, K & G Point, Bee Aye Point, and Japan Cove (**Figure 1**). The Shack is most ridable with west swell that will not pass over the restoration reefs. K & G, Bee Aye, and Japan Cove surf breaks are all best with swells from the south or south-southeast (Cleary and Stern, 1963). These swells will not pass over the restoration reef prior to reaching Japan Cove. They will, however, pass over the restoration reef before reaching K & G and Bee Aye.

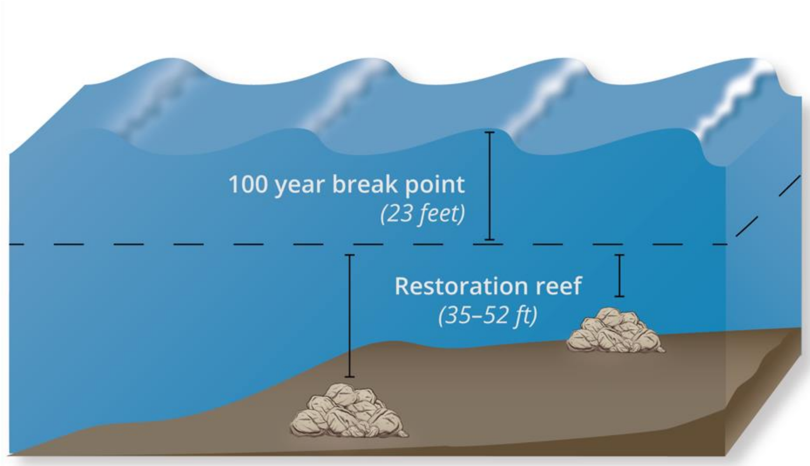

Figure 2. *A representation of the proposed restoration reef showing depth at maximum reef height and the depth at which a 100-year-wave would break.*

To determine whether the restoration reef will affect surfing conditions at these two sites, two interactions between swell and existing or proposed reef were considered. First, the water depth between mean sea level (MSL) and the top of the reef is between 10.6 and 15.8 m (35 and 52 ft; **Figure 2**). The corresponding ratio of wave height to water depth has the critical value of 0.78 (USACOE, 1984). This means that when the wave height reaches a value 0.78 times the water depth, the wave will break. Therefore, in order for the waves to break over any portion of the restoration reef, wave heights would need to exceed 8.5 m (28 ft; **Table 1**).

Mean wave heights at the restoration site are only about 1 m (3.3 ft) and exceed 1.5 m (5 ft) less than 20% of the time (CH2M Hill, 2007). Wave activity peaks in the winter (December–March) where maximum significant wave heights reach 3-4 m (9-13.2 ft) with 14- to 17-second periods during large storms (Wiberg et al., 2002). Large waves that are generated on or near the shelf have a wave height of about 2 m (6.6 ft), a period of 10 seconds, and arrive between five and ten times a year. Open-ocean waves, with a height of 2 m (6.6 ft) and 14- to 17-second periods, arrive about once a year. Waves propagating eastward from the open ocean arrive with a period of about 16- to 17-seconds and an approximate height of 3-5 m (9-16.5 ft) about once in 3 years (Seymour et al., 1984). Maximum wave heights of 5-8 m (16.5-26.4 ft) with 16- to 18-second periods are expected every five to ten years (Kolpack, 1987). These heights were recently met by swell from Hurricane Marie in August 2014 which generated maximum wave heights of 4.5-7.6 m (15 to 25 ft – estimates vary by source) from the south and closed coastal access points at Palos Verdes to the public. This event met or exceeded the predicted 100-year-wave height for the region (5.5 m/18 ft), a height that was last reached by Hurricane Linda in 1997 and would cause waves to break at a depth of 7 m (23 ft). Wave conditions along the Rancho Palos Verdes coastline are controlled by shallower natural reefs having high relief that lie inshore of the project site in water depths of about 3.9-6.1 m (13-20 ft). None of these actual or theoretical events would have caused waves to break over the restoration reef.

Table 1. *Maximum height, period, break point depth, and frequency of wave types at Palos Verdes Peninsula including wave data from the two most recent 100-year-wave events (Hurricanes Linda and Marie). Also shown for comparison are minimum depth of the proposed restoration reef and wave height necessary to break on the proposed restoration reef.*

	Wave Type	**Maximum Height (m)**	**Maximum Height (ft)**	**Period (s)**	**Break Point (m)**	**Break Point (ft)**	**Frequency**
Annual	Average	1	3.3	–	1.3	4.2	–
	Above Average	1.5	5	–	1.9	6.4	18% of days
High Surf Event	Strong Winter Storm	4	13.2	14-17	5.1	16.9	–
	Large Shelf Origin	2	6.6	10	2.6	8.5	5-10x per year
	Large Open Ocean	2	6.6	14-17	2.6	8.5	once per year
	Large Open Ocean	5	16.5	16-17	6.4	21.2	once per 3 years
	Large Open Ocean	8	26.4	16-18	10.3	33.8	once per 5-10 years
	100-Year-Wave	5.5	18	–	7.1	23.1	once per 100 years
Hurricanes	Hurricane Linda	5.5	18	–	7.1	23.1	September 1997
	Hurricane Marie	7.6	25	–	9.7	32.1	August 2014
		Wave Height to Break on Restoration Reef			**Restoration Reef Minimum Depth**		
		8.5	28		10.6	35	

The second consideration is whether the quarry rock might change regional sediment transport and deposition patterns that, in turn, might affect coastline geometry and therefore wave conditions. This concern is addressed by the concept of "closure depth" (Inman et al., 1993) which defines the water depth beyond which the ocean bottom does not change appreciably with time. The closure depth in the restoration area, where the ocean floor is at a depth of 15.2-20 m (50-66 ft), is about 9-13.6 m (30-45 ft). The restoration site is therefore located offshore of the coastal zone where regional sediment transport and deposition patterns would be affected. Consequently, the proposed restoration reef will not have an effect on nearshore sedimentation patterns or wave conditions at the adjacent surf spots.

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APPENDIX D4

BUNKER POINT REEF RESTORATION PROJECT: CRITERIA, DESIGN, AND MONITORING

PREPARED BY THE VANTUNA RESEARCH GROUP AT OCCIDENTAL COLLEGE

BUNKER POINT REEF RESTORATION PROJECT: CRITERIA, DESIGN, AND MONITORING

Vantuna Research Group

Occidental College

October 2016

EXECUTIVE SUMMARY

In this report we detail the biological, physical, engineering, and theoretical constraints for developing a subtidal rocky-reef restoration project on the Palos Verdes Peninsula. We begin with detailing the restoration need. There are well documented declines in available reef and giant kelp habitat, commercial and recreational fishing opportunities and rocky reef ecosystem health. We present the theoretical constraints and justification for restoring rocky reefs in an area of approximately 70 acres of loss habitat.

The purpose of the Palos Verdes Reef Restoration Project is to restore rocky-reef habitats and associated marine species on the Palos Verdes Shelf that were impacted by contamination in the sediments from the discharge of DDT and PCB from the Joint Water Pollution Control Plant's Whites Point Outfall (JWPCP), as well as to restore reefs that have been impacted by sedimentation and scour. This restoration project will fulfill the objective of the Montrose Settlements Restoration Program (MSRP) to restore fish and the habitats upon which they depend within the Southern California Bight (SCB). This reef will provide essential fish habitat and substrate for kelp, other marine algae, and marine invertebrates to become attached to, creating a productive rocky-reef ecosystem in an area with limited hard substrate (Claisse et al., 2012).

The amount of giant kelp and rocky reef habitat on the Palos Verdes Peninsula has declined appreciably over the last 100+ years. Originally kelp canopy loss was attributed to pollution from the Whites Point outfall; however, this deleterious problem has been ameliorated. Currently, we describe a variety of other drivers for the continued loss of this habitat (i.e., urchin barrens, sedimentation and turbidity). From Abalone Cove to Point Fermin sedimentation and associated processes are responsible for the loss of reef and kelp habitat. Landslides were the primary drivers of this process, and this latent sedimentation continues to bury reefs, reduce visibility and scour exposed habitat. This report details the documentation of these processes along this valuable stretch of coastline and, more importantly, delineates the steps necessary to restore productive habitat under these stressors.

Developing a subtidal rocky-reef restoration project of this type is a unique endeavor. Currently reefing projects in southern California have been used to construct fishing reefs (Lewis and McKee 1989), mitigate for lost kelp bed habitat (Reed et al. 2006a; Reed et al. 2006b), provide underwater scuba opportunities (e.g., Yukon), create fishery habitat in estuaries (Pondella et al. 2006) and shoreline protection from breakwaters and jetties (Stephens et al. 1994; Froeschke et al. 2005). Restoring lost habitat, *in situ*, which is currently being employed in oyster habitat and coral reefs (Rinkevich 2005; Beck et al. 2011), has not been attempted in a temperate kelp community.

In order to accomplish this objective, we generated a conceptual model of highly productive reef system based upon natural reef performance along this stretch of coastline. The next challenge is to utilize limited resources and engineering criteria to develop a restoration reef plan that maximizes the biological benefits. These benefits include insights drawn from reefs at Palos Verdes and throughout the Southern California Bight and include species richness, diversity and biomass. Our research indicates that multiple factors including reef size, spacing, relief, rock size, heterogeneity, depth, sediment depth, location relative to kelp bed perimeter and flux all influence reef performance. We developed a secondary production model that specifically analyzes the production of fish biomass to evaluate reef performance. In this project, these factors were juxtaposed with the economic, physical and engineering constraints to develop the restoration plan.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

Introduction to Restoration Project Study Area

For a variety of reasons, the nearshore environment of the Palos Verdes Peninsula (Figure 1) has been intensively studied for decades. In particular, the nearshore reefs of this headland have garnered attention due to a variety of anthropogenic activities (e.g., commercial and recreational fishing, establishment of marine protected areas, giant kelp beds lost to pollution, landslides)(Stull 1987; Pondella 2009; Foster and Schiel 2010). Historically the greatest deleterious impact to the reefs at Palos Verdes was the loss of its kelp beds due to pollution from the Joint Water Pollution Control Plant's (JWPCP) Whites Point outfall. By 1960 due to untreated sewage, the only kelp left on the peninsula was at Abalone Cove and in Portuguese Bend (North 1964). To exacerbate the situation, road construction on Palos Verdes Drive triggered the Portuguese Bend Landslide in 1956. From 1956 to 1999, approximately 5.7 to 9.4 million metric tons of sediment slid onto the inner shelf (Kayen 2002). By 1999, the landslide was dewatered, slowed appreciably and now only releases sediment due to wave action. Nonetheless the biological damage has been extreme, highlighted by the loss of the Portuguese Bend Kelp Bed leaving only the Abalone Cove Kelp Bed by 1974. Due to the infrastructure improvements of the Whites Point Outfall, between 1937 and 1967 the three deep outfalls were built and currently the two deepest outfalls, which reside ~1.5 miles offshore in 200' of water are used. In 1984, partial secondary treatment of the flow (60:40 mix of secondary:primary) started and continued until late 2002 when the discharge of 100% secondary effluent began. In the early 1970s, Wheeler North kelp restoration efforts at the Palos Verdes Peninsula for giant kelp were successful and giant kelp remains present to this time.

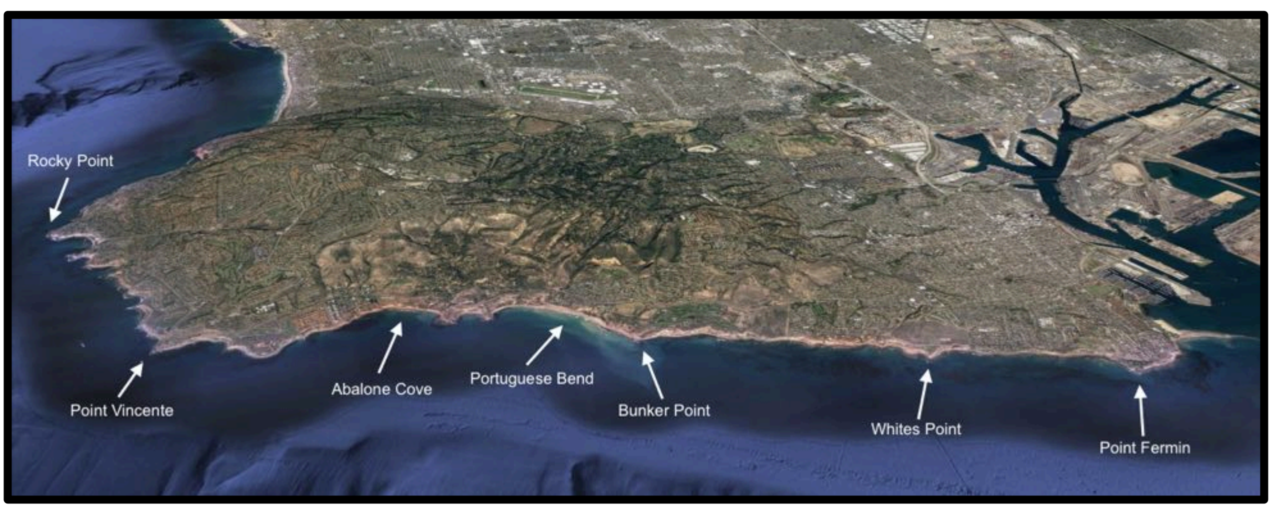

Figure 1. Satellite image of the Palos Verdes Peninsula (image adapted from NASA/JPL taken on 2/2/2016).

While these restoration and enhancement efforts ameliorated the historical consequences of the Whites Point Outfall throughout the peninsula, sedimentation and associated turbidity continue to have chronic impacts. First there is continued turbidity, sediment transport and scour associated with the sediment deposited in Portuguese Bend from the landslide (Figure 2). Turbidity currently is caused by wave action and is much reduced compared to Figure 2, which is an example of the turbidity plume prior to stabilization of the landslide. Further exacerbating this influx of sediment was the 16-acre landslide on June 2, 1999 from the 18th hole of the Trump National Golf Club, which sits above Bunker Point. Reef burial near Bunker Point was not observed during the extensive surveys of this region in the 1990s (Stephens 1996), but has been observed in more recent surveys (Pondella et al. 2012a; Pondella et al. 2015b). Proximity to the Trump National Golf Course landslide suggests that the reef has likely been buried since 1999. A third point source of turbidity and sedimentation comes from the large storm drains that empty into this nearshore environment. With these various chronic stressors there is continued deleterious impacts to the nearshore rocky environment, especially from Portuguese Bend (buried reef) to Point Fermin (Stephens 1996; Pondella et al. 2012b).

Figure 2. Turbidity plume from the Portuguese Bend landslide (left: circa 1980s; right: April 2016).

Mapping the Restoration Study Area

We examined three potential restoration area alternatives in Portuguese Bend, the West Area (Bunker Point) and the East Area (Whites Point to Point Fermin) (Figure 3). Portuguese Bend was eliminated early in the evaluation process because the sediment depth was too deep and quarry rock would sink and be buried. The restoration study area was defined as the area from just east of Bunker Point to just west of the JWPCP Outfall at Whites Point (Figure 7). The western border was defined by the high relief reef at Bunker Point and the eastern border was delineated so as not to include the Whites Point Outfall.

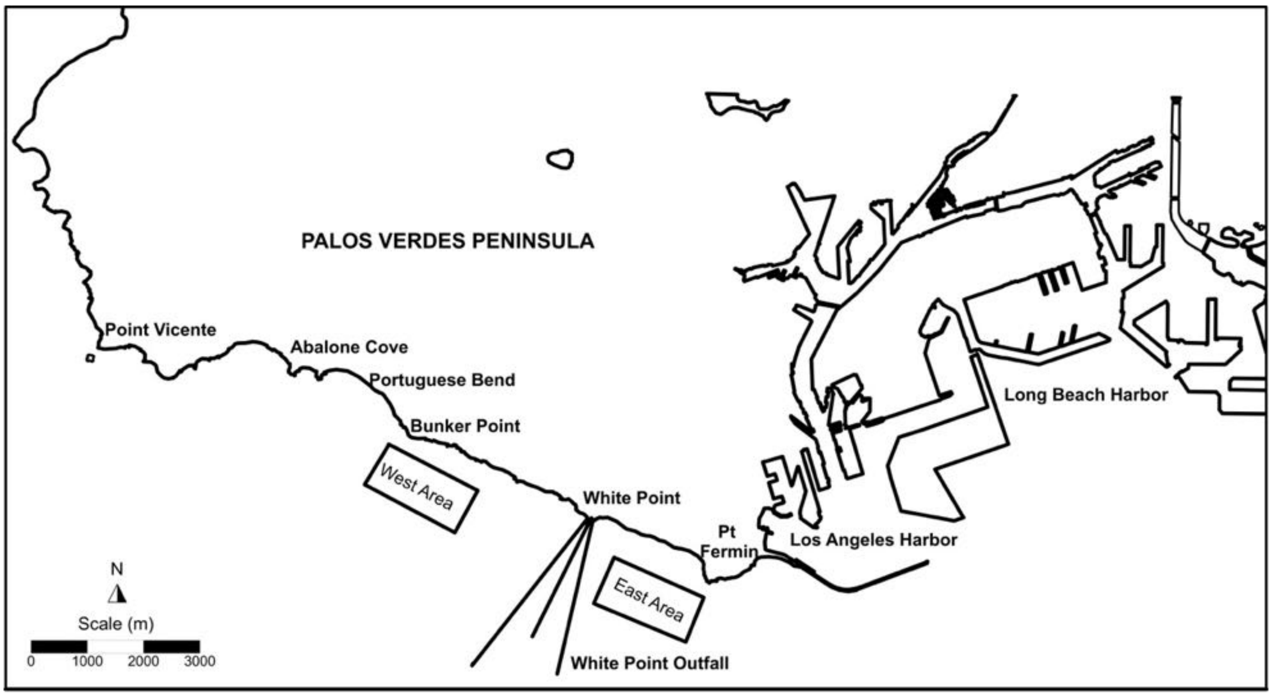

Figure 3. Location of the two proposed sites (West area and East area) for the Palos Verdes Reef Restoration Project, showing major landmarks in the area

The southern border is approximately the 30 m isobath and the northern border is the shoreline. This area consisted of approximately 2.9 km^2 (2,899,280 m^2) of nearshore environment. The geographic extent and character of marine hard bottom/reef was mapped by combining several different spatial datasets into a preliminary habitat data layer (Claisse et al. 2012). This layer was then verified and corrected using underwater field observations and analyses of aerial and satellite photography. All mapping and spatial analysis was done using ArcGIS software. Spatial data layers were created and maintained in the shapefile format, using the UTM Zone 11 North, WGS84 projection to minimize distortion in both area and length measurements. Kelp canopy was a highly precise polygon spatial layer created by using a 2-meter rectangular grid to classify georeferenced aerial photography (Kelner 2005). Kelp canopy varies significantly over seasons and years and has decreased well below historical levels (Figure 4,6). In this layer several years

(2008 and 2011-2014) of data was used additively. This project area is outside the kelp canopy but inside the area where historic kelp was found (Figures 5,7). Reefs are buried and /or suffer from scour at this depth prohibiting historical kelp growth (Pondella et al. 2012b). Triple beam and side scan sonar data were obtained from the Sea Floor Mapping Lab at California State University, Monterey Bay.

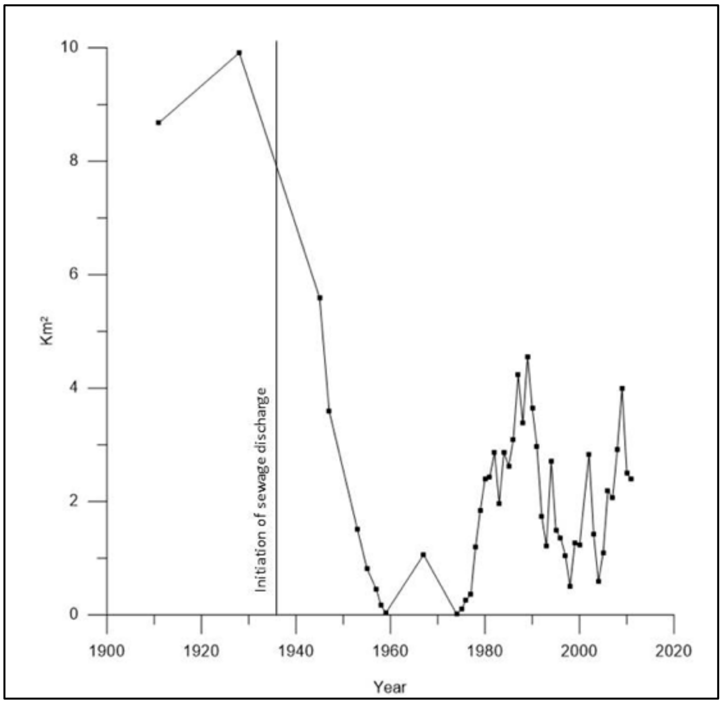

Figure 4. Kelp canopy coverage (km2) from 1911 – 2011 on the Palos Verdes Peninsula (data from MBC, 2012).

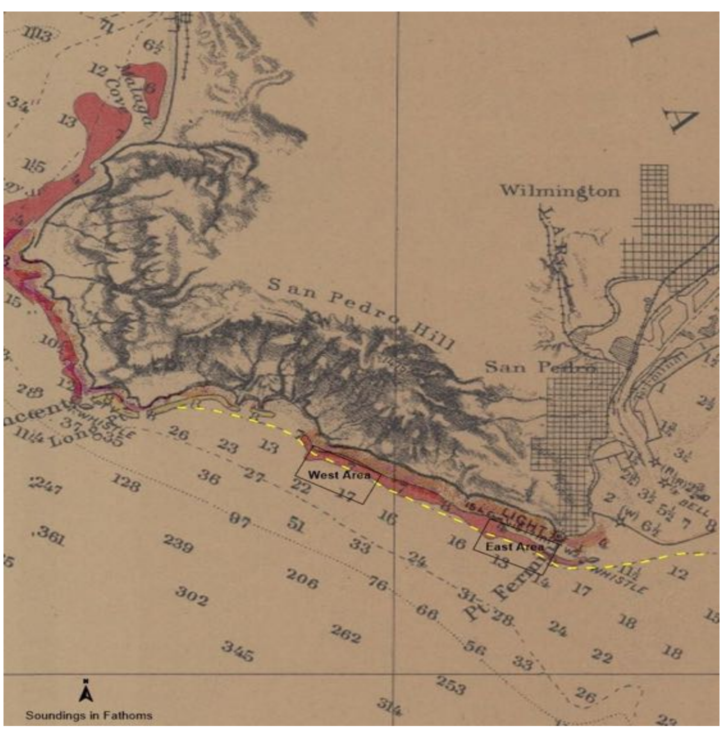

Figure 5. Locations of kelp beds along Palos Verdes in 1911 based on the Crandall survey (red shading). The orange shading shows a composite of kelp canopy data from the CDFW from 1988, 1999, 2002, 2004, 2005, 2006, 2008, and 2009. Purple shading shows kelp canopy data from the CDFW from 2013. From this map, it can be seen that the kelp canopy in 1911 was located up to the 10 fathom (18 m) line (yellow dashed line). Current kelp canopy coverage extends to 15 m depths.

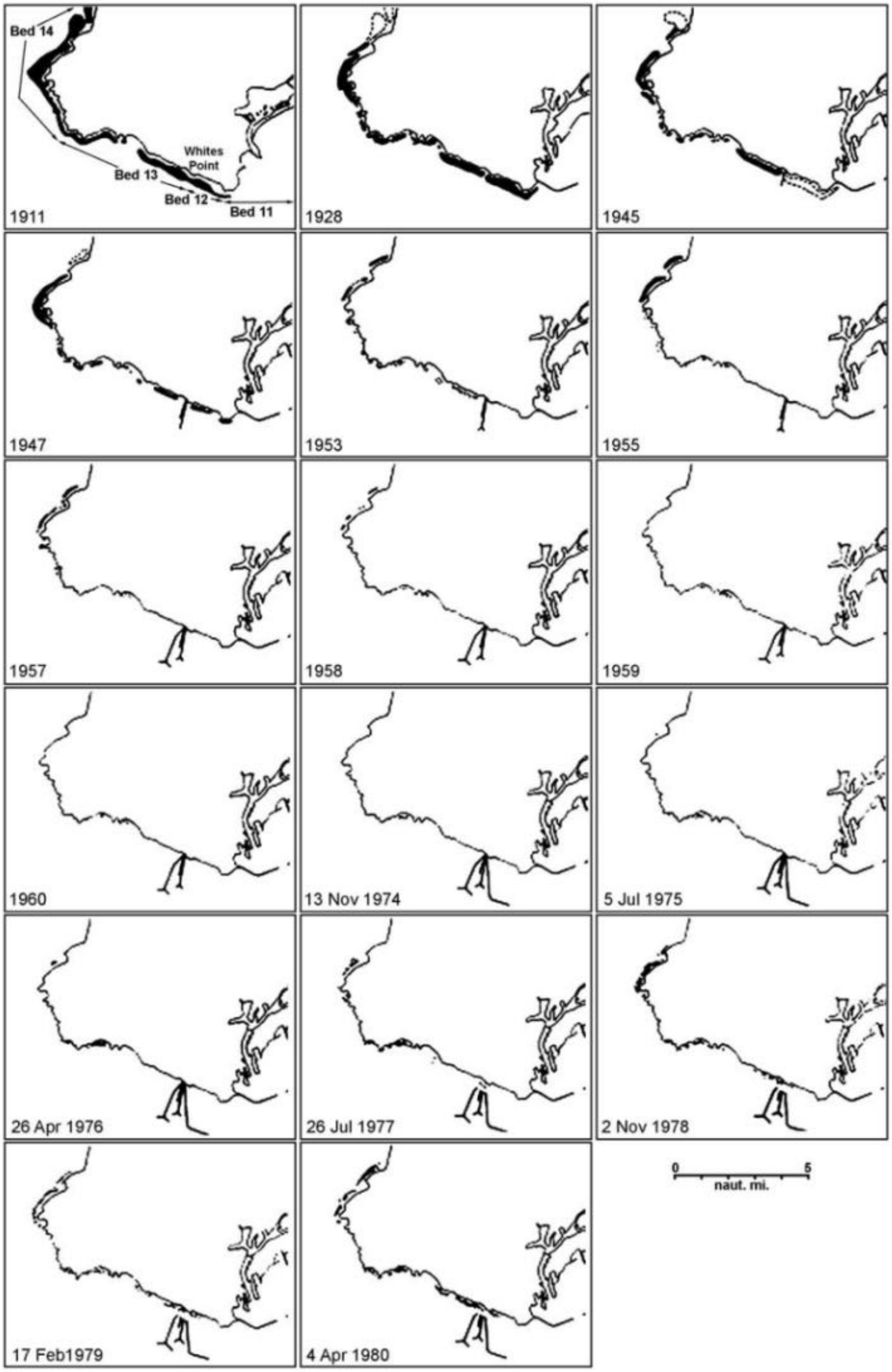

Figure 6. Kelp coverage on the Palos Verdes Peninsula in selected years between 1911 and 1980 (figure from MBC, 2012).

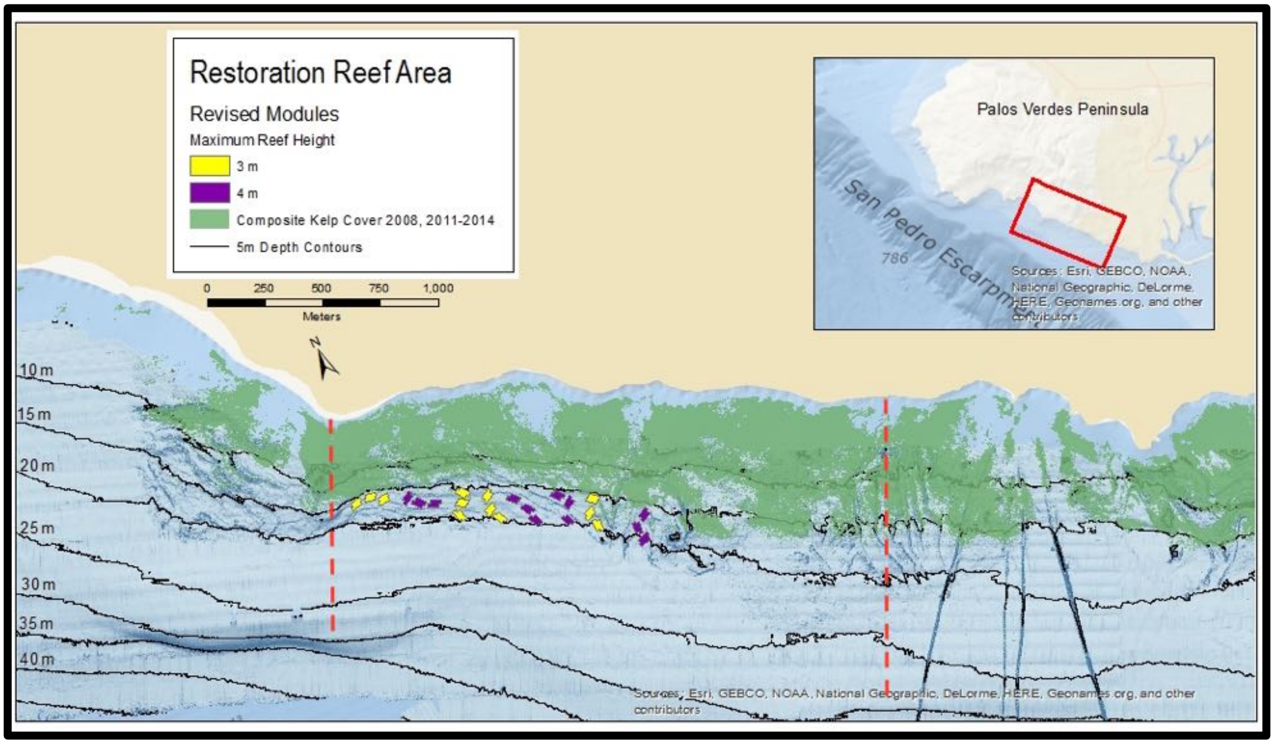

Figure 7. Bunker Point restoration site study area with kelp canopy, side scan imagery, and isobaths in 5-m increments. Western and eastern boundaries for the study area are shown as dashed red lines. This map also includes the proposed locations for the restoration reef blocks. Blocks have a maximum reef height of either 3 m (yellow) or 4 m (purple). The characteristics and placement of each block are described in more detail later in the report.

COMPREHENSIVE MONITORING OF REEFS AROUND PALOS VERDES PENINSULA

We examined the potential efficacy of fishery production enhancement reefs in this region by conducting an intensive biological and physical sampling program throughout the subtidal areas of Palos Verdes Peninsula. As part of multiple kelp forest monitoring programs we have conducted 578 surveys at 38 sites from 2004-2015 in this region (Figure 8, Table 1) using the CRANE protocol. This is a standardized comprehensive community monitoring survey method that quantifies fishes, invertebrates, algae and habitat characteristics within multiple depth zones at each site (for more details on the protocol see Claisse et al. 2012; Pondella et al. 2015a; Pondella et al. 2015b; Zahn et al. 2016). This protocol is focused primarily on sampling rocky reef habitats, and therefore areas that are primarily soft bottom, including the proposed locations for the restoration reef blocks, were sampled with additional supplementary methods (see Sediment Depth Surveys below). In order to determine the effects of the sedimentation and turbidity on rocky reef habitats around the Palos Verdes Peninsula, we conducted a habitat characterization utilizing metrics generated from uniform point contact (UPC) data from the comprehensive kelp forest monitoring dataset. The physical substrate and relief of reefs varied throughout the peninsula. Most of the variation in substrate was associated with the fraction of sand versus bedrock, and most of the variation in physical relief was associated with the proportion of flat (0 – 0.1 m) reef versus moderate (1-2 m) and high relief (> 2m) reef. The restoration study area was characterized by flat to low relief reef with larger portions of sand, cobble, and boulders versus other areas of the peninsula where bedrock reefs are the dominant feature.

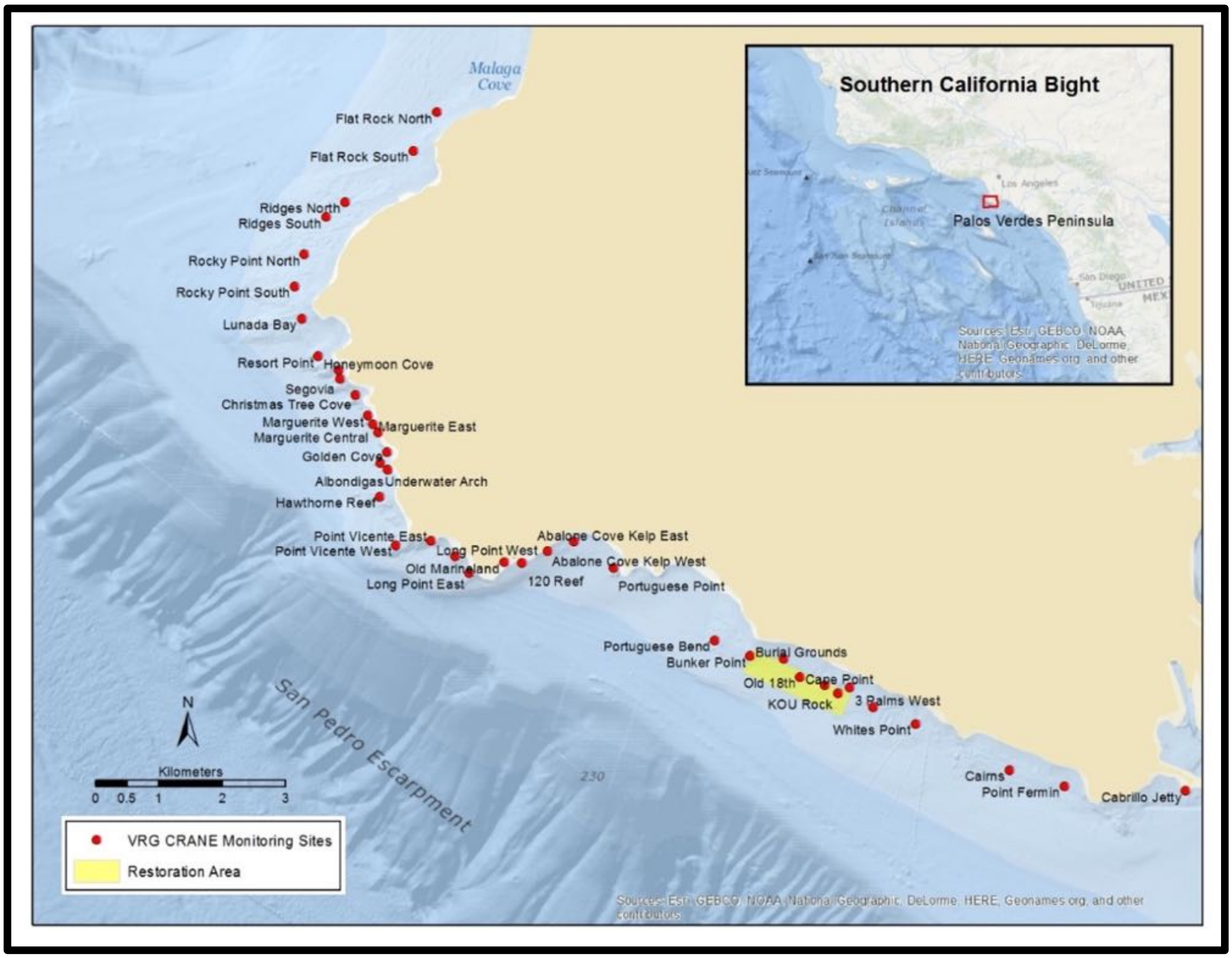

Figure 8. CRANE monitoring sites around the Palos Verdes peninsula with the restoration area (yellow).

Table 1. Sites surveyed using CRANE protocols by year, listed from northwest to southeast (Figure 8). The sites surveyed within the restoration area are indicated in gray. CRANE protocols require >50% coverage of rocky reef, the restoration area has not supported kelp or significant percentages of rocky substrate precluding it from previous CRANE surveys.

Site	2004	2007	2008	2009	2010	2011	2012	2013	2014	2015
Flat Rock North		X	X							X
Flat Rock South		X								X
Ridges North	X	X		X	X	X	X	X	X	X
Ridges South	X	X	X				X	X	X	X
Rocky Point North	X	X	X	X		X	X	X	X	X
Rocky Point South		X			X	X	X	X	X	X
Lunada Bay						X	X	X		X
Resort Point			X				X	X	X	X
Honeymoon Cove						X	X	X	X	X
Segovia							X	X		X
Christmas Tree Cove					X	X	X	X	X	X
Marguerite West						X	X	X	X	X
Marguerite Central						X	X	X	X	X
Marguerite East						X	X	X	X	X
Golden Cove						X	X	X	X	X
Underwater Arch					X		X	X		X
Albondigas						X	X	X	X	X
Hawthorne Reef		X		X	X	X	X	X	X	X
Point Vicente West	X	X	X	X	X	X	X	X	X	X
Point Vicente East		X								
Long Point West		X					X	X		X
Long Point East		X		X	X	X	X	X	X	X
Old Marineland						X	X	X		X
120 Reef					X	X	X	X		X
Abalone Cove Kelp West					X	X	X	X	X	X
Abalone Cove Kelp East					X		X			
Portuguese Point					X		X	X		X
Portuguese Bend								X		X
Bunker Point		X				X	X	X	X	X
Burial Grounds										X
Old 18th								X		X
Cape Point										X
KOU Rock				X		X	X	X	X	X
3 Palms West		X						X	X	X
3 Palms East		X	X	X					X	X
Whites Point		X	X		X	X	X	X	X	X
Cairns						X	X	X	X	X
Point Fermin		X	X		X	X	X	X	X	X

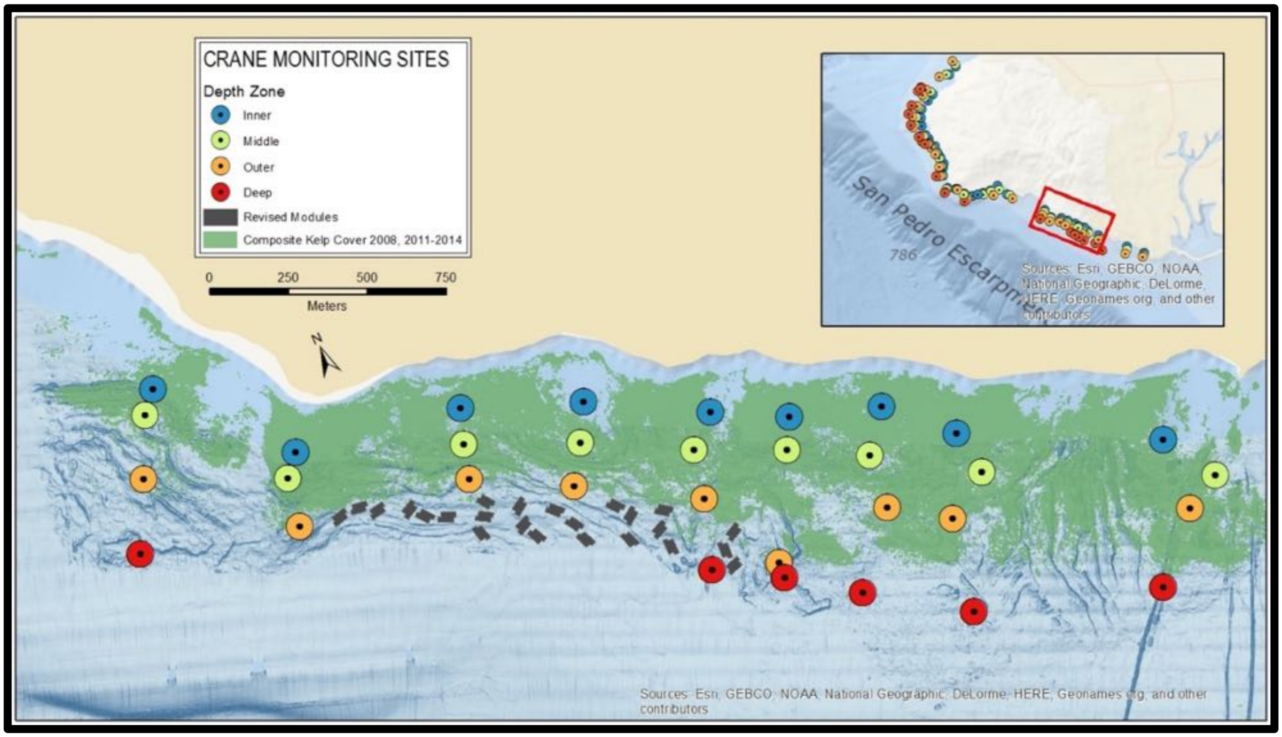

Figure 9. Mapped reef habitat, composite kelp cover, and subtidal survey locations by depth zone with currently proposed restoration reef blocks (gray). Multiple depth zones (Inner, Middle, Outer, Deep) are surveyed at each CRANE monitoring site.

The most striking aspect of the benthos was the evidence of sedimentation effects in the study area as well as surrounding reefs. Sedimentation effects are evident upcoast and downcoast based upon the direction of the longshore current and suspension by swells. We observe these effects from Abalone Cove (ending at Long Point) through Whites Point (Figure 9). Bare rock cover on rocky reefs can be an indicator of scouring by either abiotic sources (e.g., sand, shell hash, wave action) and is typical of areas that are under stresses of high flow and/or high sedimentation (Figure 10). The proportion of abiotic cover (including bare rock, bare sand, shell hash, sediment, and detritus) on rocky reefs was far higher in sedimentation affected areas, such as those near storm drains, landscaping runoff zones, and landslide areas and is what we found in the study area (Figure 11). Biological indicators of sedimentation effects include the benthic cover proportion of sediment resistant tubeworms, including *Phragmatopoma californica*, *Salmacina tribranchiata*, and *Diopatra ornata* (Figure 12). These three metrics provide insight into the extent of ecosystem damages caused by various forms of sedimentation along Palos Verdes Peninsula.

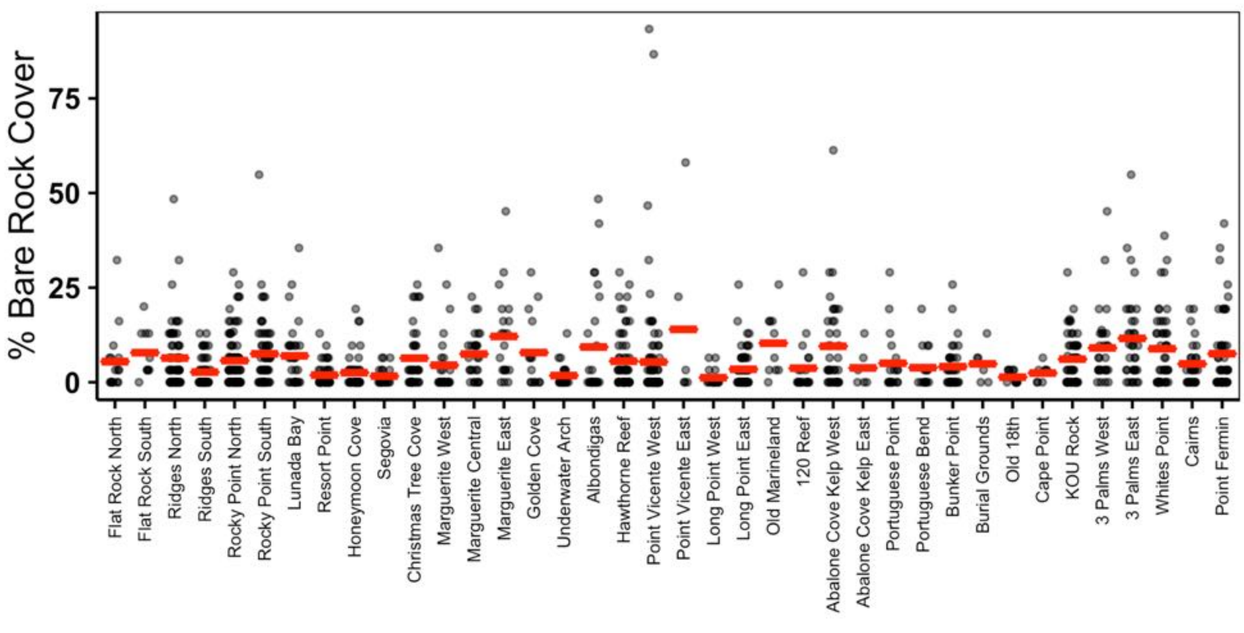

Figure 10. Percentage of bare rock cover on rocky reefs at each site along Palos Verdes Peninsula. Dots represent values for every transect, red crossbars represent mean values.

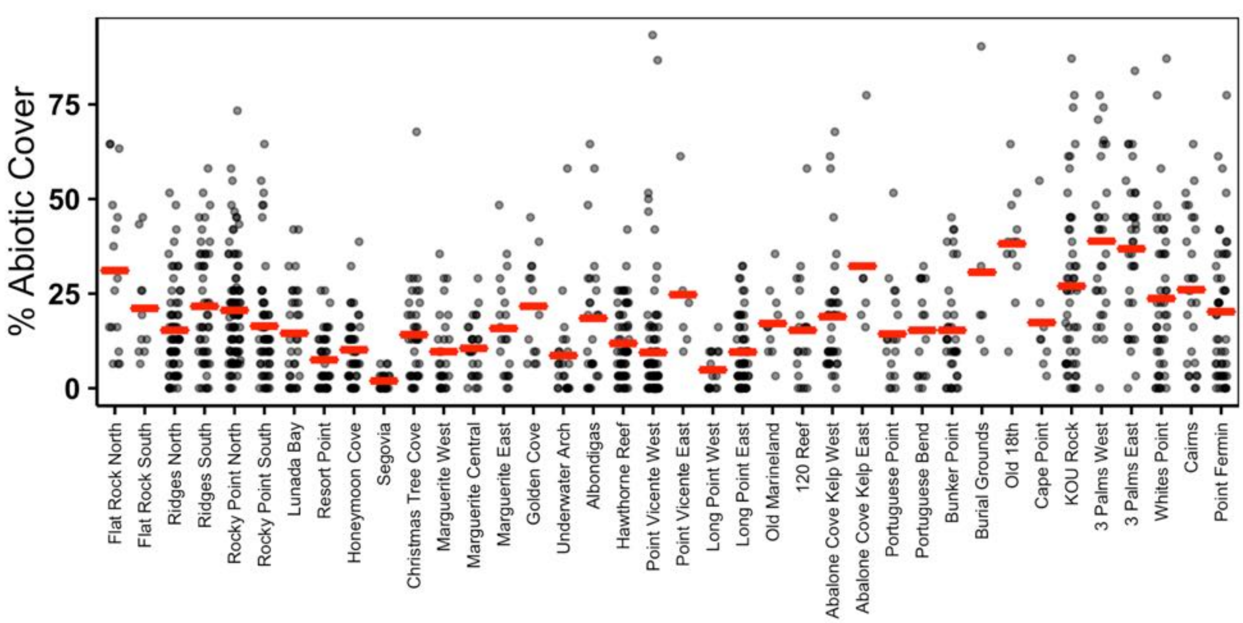

Figure 11. Percentage of abiotic cover (including bare rock, bare sand, shell hash, sediment, and detritus) on rocky reefs at each site along Palos Verdes Peninsula. Dots represent values for every transect, red crossbars represent mean values.

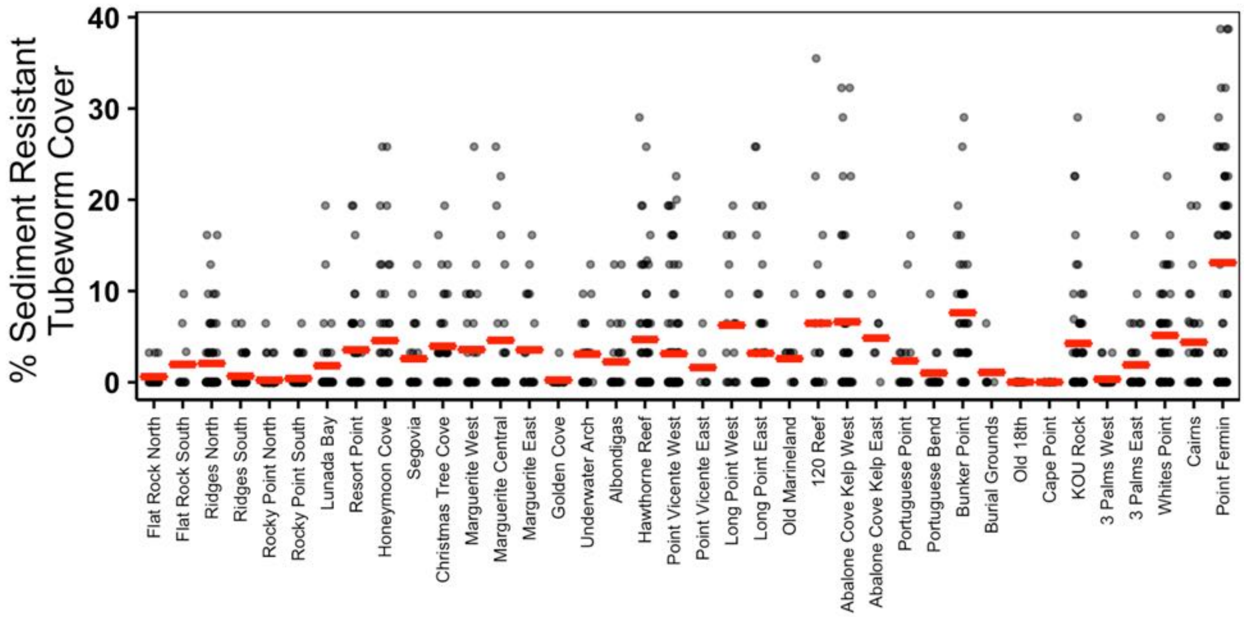

Figure 12. Percent sediment-resistant tubeworm cover on rocky reefs at each site along Palos Verdes Peninsula. Dots represent values for every transect, red crossbars represent mean values.

A second part of the CRANE subtidal survey protocols (swath) was used to determine macroalgal and macroinvertebrate densities in conjunction with the UPC surveys at each reef. Macroalgal densities provided insight into the community structure of each reef and the presence or absence of appropriate habitat for fishes and invertebrates that depend on macroalgae for food and/or shelter. While macroalgae along the Palos Verdes Peninsula consisted of several species, including giant kelp *Macrocystis pyrifera*, *Pterygophora californica*, *Laminaria farlowii*, and other understory kelps, giant kelp was the lone canopy creating species. Reefs with dense giant kelp forests require relatively clear, nutrient rich water, and are considered to be among the most productive areas in southern California. Giant kelp forests were found inside the restoration study area, but were far thinner and more ephemeral than in areas with less turbidity and sedimentation issues (Figures 13 & 14). *Pterygophora californica* creates understory canopies on flatter, low-relief reefs, and can withstand more turbidity than giant kelp. This macroalgae was found in high densities in the sediment-affected reefs in the study site, creating an understory in addition to the sparse giant kelp canopy (Figure 15). However, many of these individual kelps were completely denuded of blades and their stalks were parasitized by epiphytic macroalgae including giant kelp and *Laminaria farlowii*. It was hypothesized that these atypical epiphytes used the hearty stalks as substrate for their holdfasts largely as a product of availability versus natural substrate due to sedimentation effects.

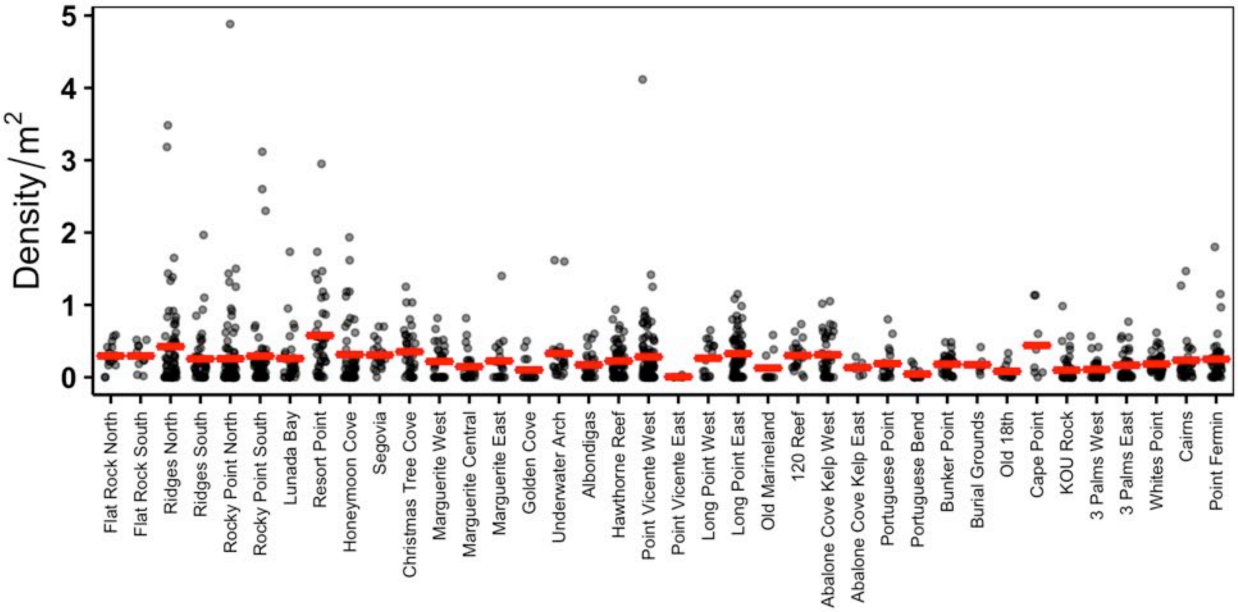

Figure 13. Giant kelp (*Macrocystis pyrifera*) density on rocky reefs at each site along Palos Verdes Peninsula. Dots represent values for every transect, red crossbars represent mean values.

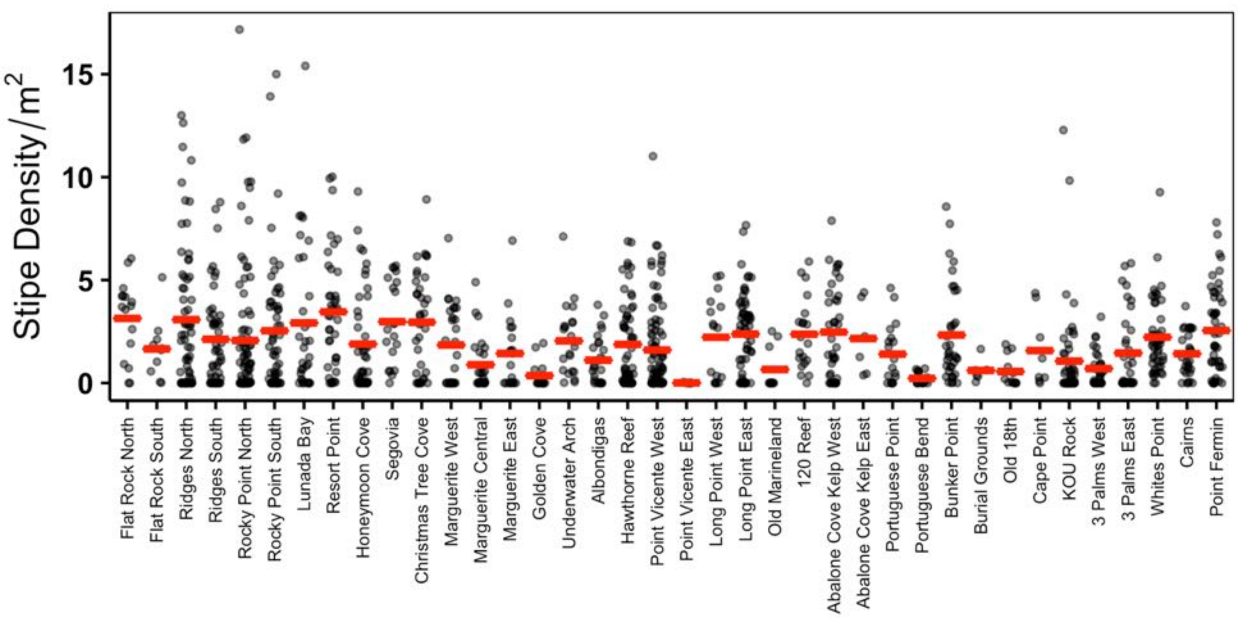

Figure 14. Giant kelp (*Macrocystis pyrifera*) stipe density (stipes per m^2) on rocky reefs at each site along Palos Verdes Peninsula. Dots represent values for every transect, red crossbars represent mean values.

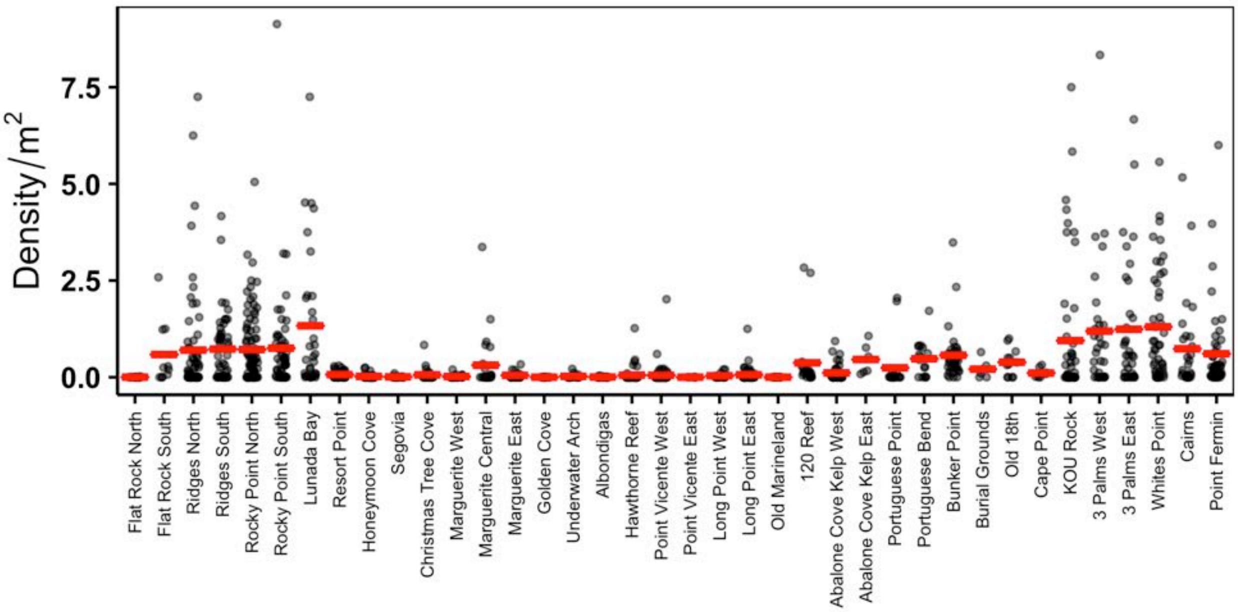

Figure 15. *Pterygophora californica* density on rocky reefs at each site along Palos Verdes Peninsula. Dots represent values for every transect, red crossbars represent mean values.

SEDIMENT DEPTH SURVEYS

We conducted supplementary scuba surveys at 9 locations to determine the sediment depth over rocky reef throughout this area (Figure 16) in an effort to better characterize soft bottom habitat areas in the study area and determine proposed locations for the restoration reef blocks. These surveys were conducted perpendicular to the coastline starting at the 20 m isobath, and divers would measure the sediment depth at 10 m intervals until completely uncovered and unbroken reef habitat was found. Sites that were found to be primarily exposed rocky reef were excluded from successive surveys. The initial sediment characterization was conducted in Spring 2009 and a second survey was conducted in Spring 2010. A third survey was conducted in Spring 2011 to fill in spatial gaps and further concentrate surveys on possible restoration sites. Between each of the first three study periods we had long winters of cold El Niño storms associated with heavy rains. This set up a natural experiment of the effects of heavy swell and rain on the study site, and helped determine fidelity of buried reefs (Pondella et al. 2012). A final survey was conducted in 2013 at sites that were considered prime options for restoration as a product of the previous surveys, all of which were across large, well-defined areas of buried rocky reef. While sediment depth and the amount of rocky reef covered by sand remained buried over time, no previously identified buried reefs were cleared of sand during this period (Table 2). Consistent with the visual observations of the *Pterygophora* beds, these findings indicated that reef habitat continued to be buried at proposed locations for the restoration reef blocks.

Table 2. Sediment depth survey results summarized as mean sediment depth and percentage of exposed and buried reef by line (Figure 16) and survey year.

	2009	2010	2011	2013		2009		2010		2011		2013	
Line #	Mean Sediment Depth (cm)					% Exposed	% Buried	% Exposed	% Buried	% Exposed	% Buried	% Exposed	% Buried
1	19.2	–	–	–		71	29	–	–	–	–	–	–
2	8.7	4.5	21.4	3.3		60	40	15	85	11	89	30	70
13	–	–	10.7	8.7		–	–	–	–	15	85	20	80
3	3.2	10.7	4.0	10.8		0	100	0	100	10	90	18	82
4	2.6	6.0	–	–		22	78	42	58	–	–	–	–
5	–	21.3	–	–		–	–	0	100	–	–	–	–
6	3.0	–	–	–		38	62	–	–	–	–	–	–
7	3.0	5.5	10.3	7.4		0	100	8	92	27	73	20	80
8	1.9	4.6	5.4	4.6		40	60	0	100	26	74	41	59

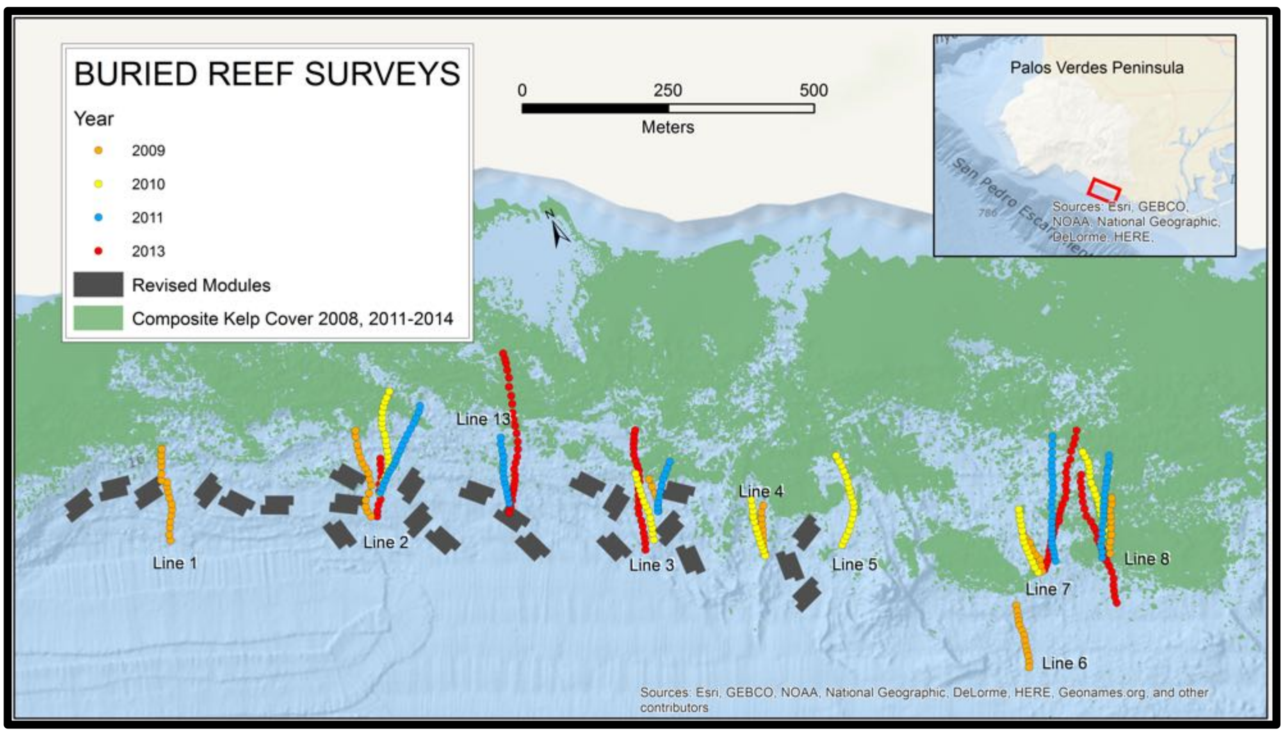

Figure 16. Mapped reef habitat, composite kelp cover, and yearly sediment survey locations with currently proposed restoration reef blocks.

Proxy Reef Surveys

In order to further our understanding of how reef shape, size, structure, and relief affect the fish, invertebrate, and macroalgal communities, 25 isolated reefs along and adjacent to Palos Verdes Peninsula at depths of 16-24 m were surveyed using CRANE protocols (Figure 17). These reefs included six natural reefs, 10 manmade reefs built with quarry rock, three shipwrecks, three sites with scattered debris, two sites with quarry rock resting on discharge pipes, and one site with engineered shelters. In addition to typical survey techniques, total reef height was also measured by recording depth at the bottom and top of the reef. During these surveys and all other subtidal surveys using CRANE protocols, fish densities were calculated by identifying, counting, and estimating the sizes of all conspicuous fishes throughout the water column. Fish length estimates were converted to biomass using standard species-specific length-weight conversions from the literature (e.g., Claisse et al. 2012; Williams et al. 2013) or FishBase (FishBase 2012).

Total fish biomass was generally found to be higher on the manmade quarry rock reefs than on the natural reefs, and there was positive relationship between fish biomass and total reef height for each habitat type (Figure 18). Quarry rock reefs performed better at lower heights when compared to natural reefs, most likely due to the increased rugosity and interstitial space afforded by the piled quarry rock, as opposed to the generally solid bedrock formations of a natural reef. These results are consistent with another study comparing manmade (primarily quarry rock) reefs with natural reefs in southern California (Granneman 2011; Granneman and Steele 2014). They found that manmade reefs had higher rugosity than natural reefs and that fish tissue production was positively correlated with the abundance of large boulders. On average, mean biomass for quarry rock artificial reefs we studied was 63 g/m^2 when reef height was less than 1.5 m, while mean biomass for isolated natural and manmade quarry rock reefs greater than 1.5 m in height was 189 g/m^2 (Figure 19).

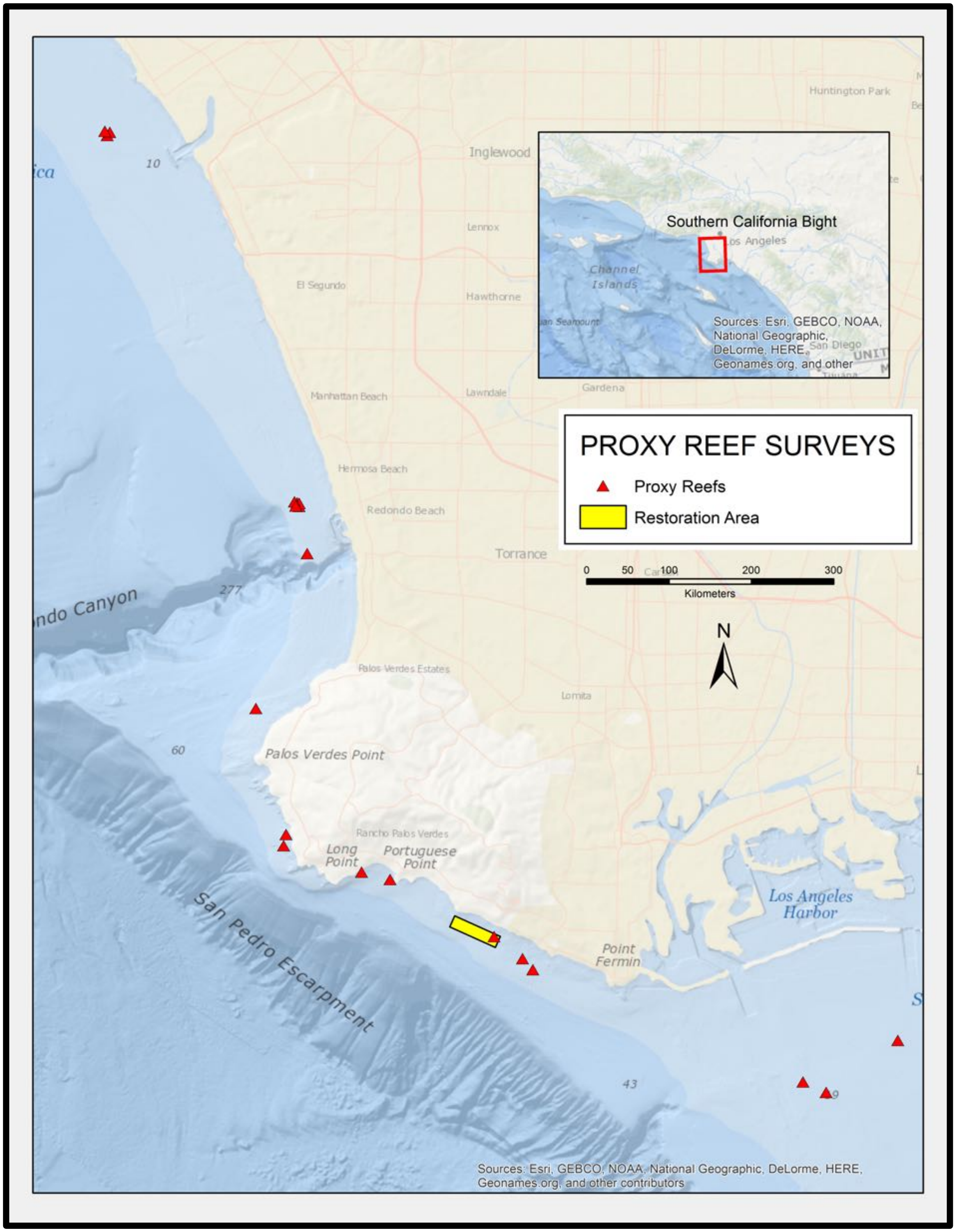

Figure 17. Location of artificial and high-relief natural reefs at Palos Verdes Peninsula and in Santa Monica and San Pedro Bays that were studied using CRANE surveys.

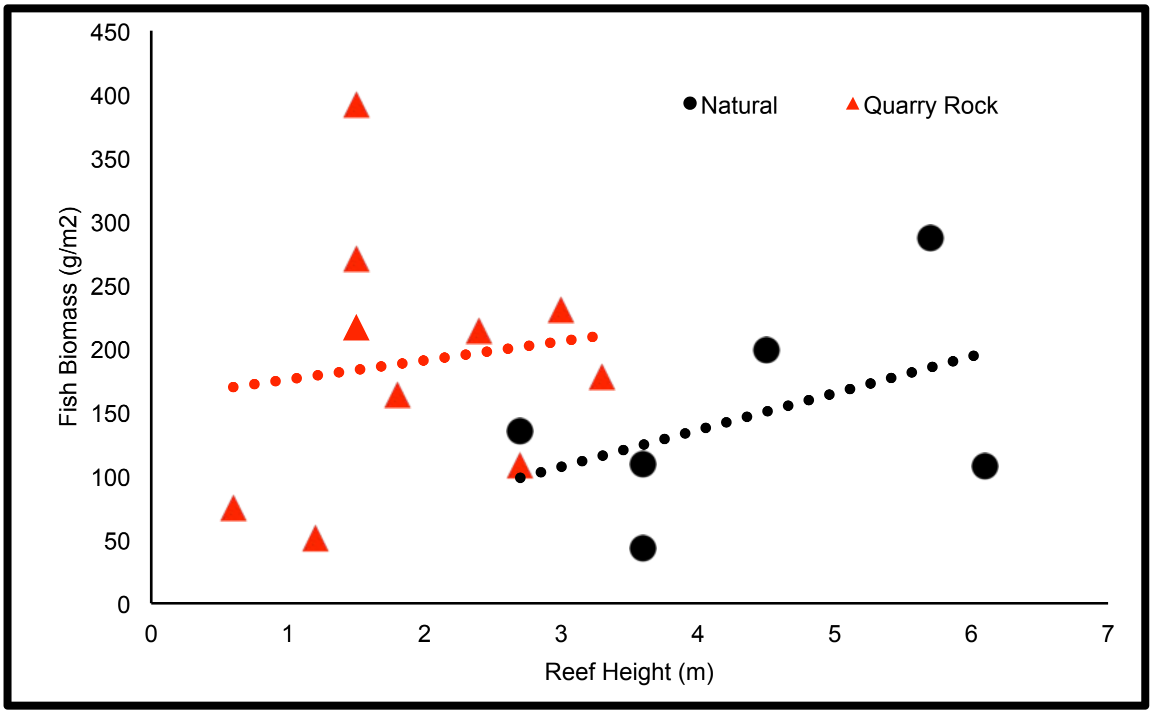

Figure 18. Reef height by total fish biomass (excluding young-of-the-year and pelagic species) at both natural isolated reefs and artificial reefs at Palos Verdes Peninsula and Santa Monica and San Pedro Bays.

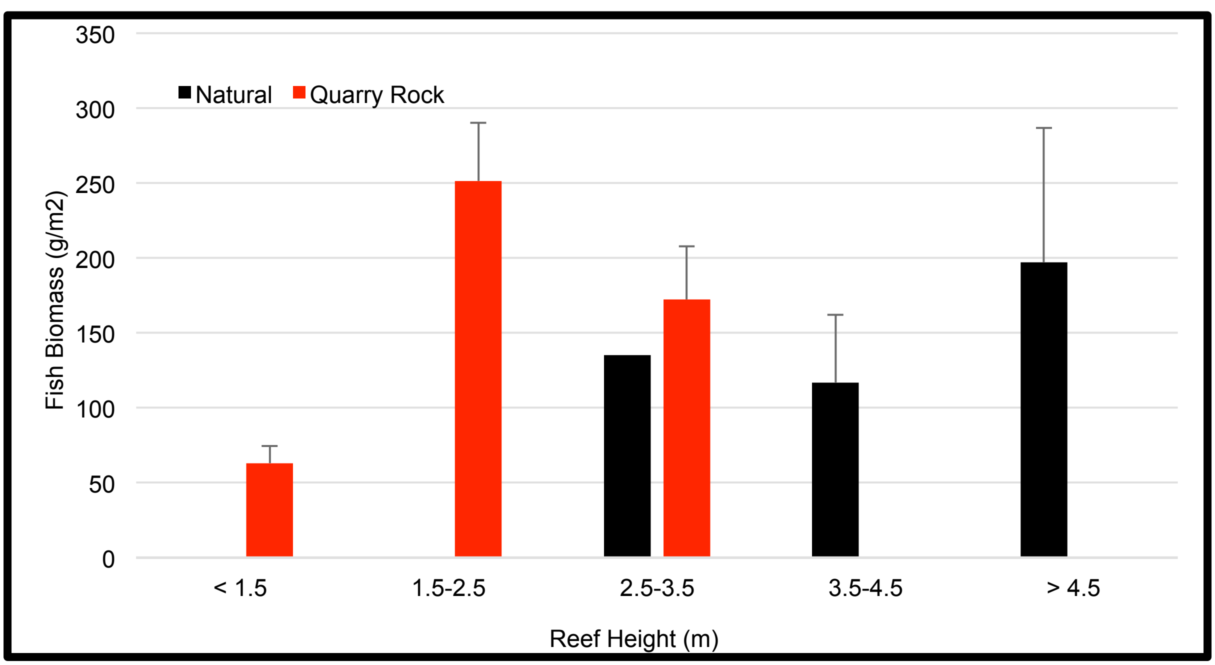

Figure 19. Mean reef height by total fish biomass (excluding young-of-the-year and pelagic species) at both natural isolated reefs and artificial reefs at Palos Verdes Peninsula and Santa Monica and San Pedro Bays.

HIGHLY PRODUCTIVE PALOS VERDES REEFS

Illustrating the complexity of this system, in spite of the sedimentation and turbidity problems from Bunker Point to Whites Point, the biomass and production potential for commercial and recreational fish species of the reefs was remarkably high where rocky reefs are present above the sediment. The biomass of kelp bass *Paralabrax clathratus* was higher at nearly every reef from Portuguese Bend to Cairns compared to the rest of the peninsula (Figure 20). California Sheephead, *Semicossyphus pulcher*, showed similar patterns, specifically from Portuguese Bend to KOU Rock, and at sites within MPAs (Long Point East and Point Vicente West; Figure 21). The reason for this increased biomass of fishery species in the area may reflect differential fishing pressure around the peninsula and/or elevated production along this stretch of coastline. Most salient to the design of the restoration reef is the total fish biomass at each site and depth zone (Figure 22). A typical reef along Palos Verdes Peninsula has the highest amount of fish biomass in the middle (~10 m) and outer (~15 m) depth zones. Notable among all depth zones and sites is the outer depth zone at the site named KOU Rock, which consistently has the highest fish biomass among anywhere on the peninsula averaging over 300 g/m^2. This semi-isolated pinnacle reef is inside the restoration project study area and subject to the same turbidity and sedimentation pressures as other reefs in the area, but its high (~5 m) total relief prevents accumulation of and burial under sediment. This reef was and continues to be the model for proposed restoration reefs at the study site. Details of the reef design are provided in subsequent sections.

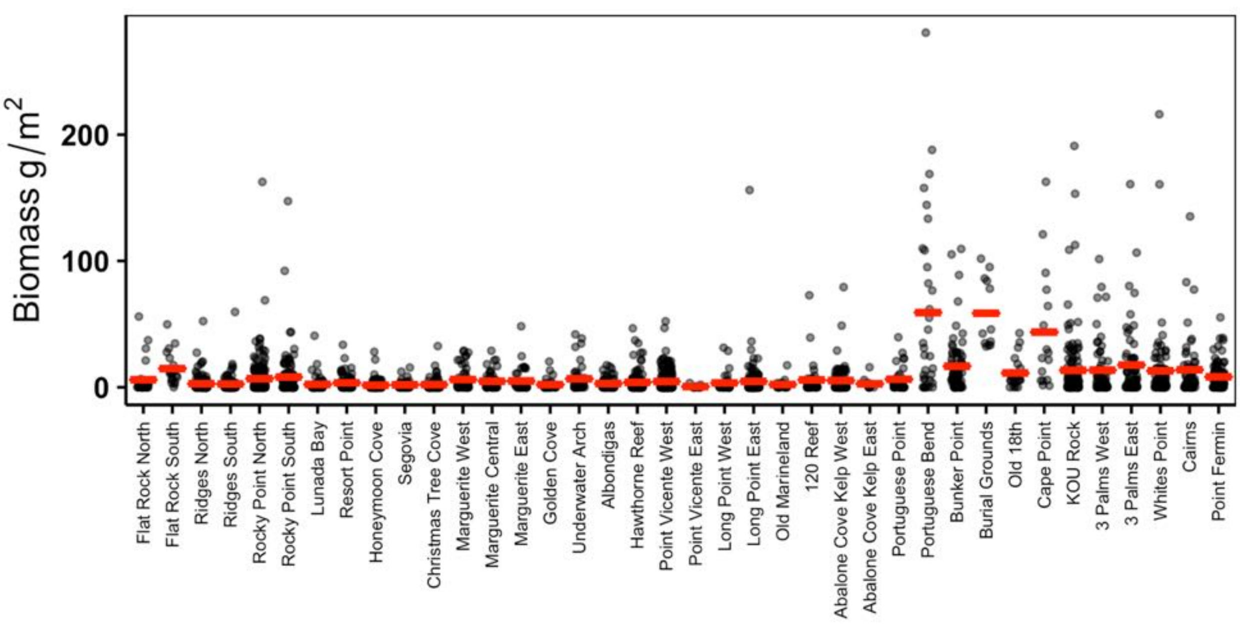

Figure 20. Biomass density of Kelp Bass (*Paralabrax clathratus*) at each site along Palos Verdes Peninsula. Dots represent values for every transect, red crossbars represent mean values.

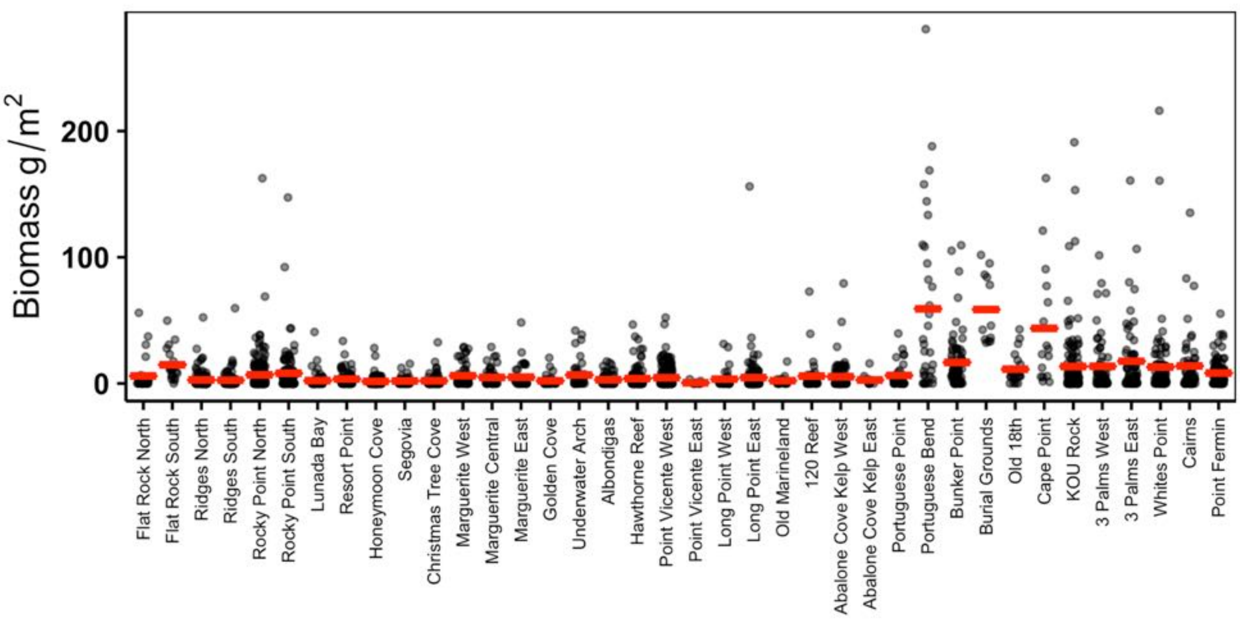

Figure 21. Biomass density of California Sheephead (*Semicossyphus pulcher*) at each site along Palos Verdes Peninsula. Dots represent values for every transect, red crossbars represent mean values.

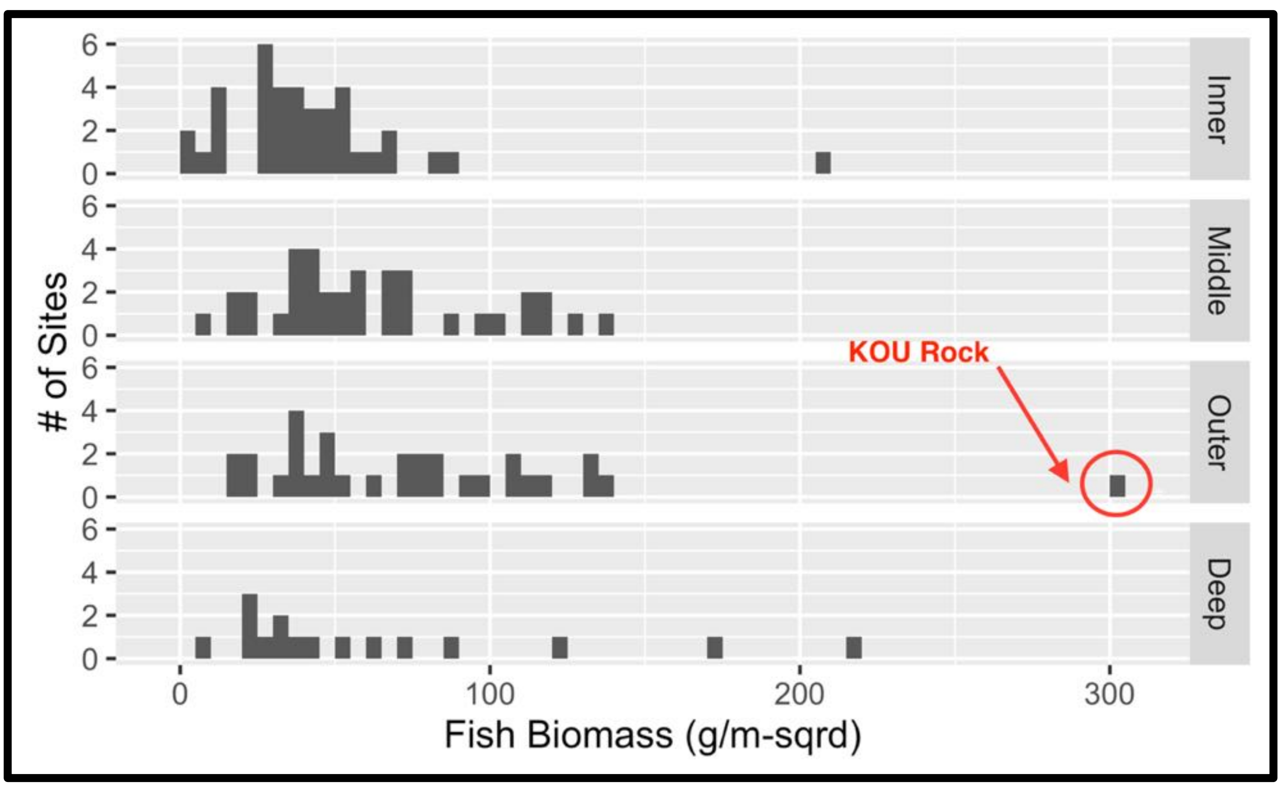

Figure 22. Distribution of total fish biomass at sites within specific depth zones. Note young-of-the-year and pelagic species are excluded from biomass estimates; The outer depth zone at the site named KOU Rock is where the large semi-isolated pinnacle reef is located in the restoration project study area. This high relief reef in the outer depth zone (surveyed six times from 2009-2015) is highlighted here as it served as the general model for the restoration reef design.

RESTORATION REEF DESIGN

The restoration reef is designed as set of eight “blocks” (Figures 23-25). Each block contains three modules (A, B, C). Each module consists of a 3 x 2 set of six “piles”. The three piles on each side of the module are offset by 1/2 of the pile width (8 m). Each pile is a 16 m x 16 m square pyramid of quarry rock with an overall height of 1 m, 2 m, 3 m, or 4 m (Figure 23). The blocks will be in two designs, either with a 3 m overall pile height or a 4 m overall pile height. There is a 10 to 20 m wide sand channel between modules and at least 50 m of space between blocks. These distances were chosen due to the previously described ‘halo’ effect around reef of ~30 m (Johnson et al. 1994). Reef modules that are separated by < 30 m are more likely to operate as a single reef for many species, while blocks separated by > 30 m operate more independently (Pondella et al. 2006). In our design criteria reef blocks are spaced at least 50 m apart. By separating the blocks and modules by the appropriate distances we can restore a greater amount of reef perimeter sand-rock ecotone habitat and we can increase the independence of replicate reef blocks. The overall approach is to try to balance scientific study design considerations with maximizing the potential for an effective restoration effort across the range of important species, and kelp forest biodiversity. Major motivations included incorporating heterogeneity throughout the restoration reef design both within (e.g., varying pile heights within blocks) and amongst (e.g., varying block orientation across blocks) the reef blocks. Specific design elements and block placement considerations are discussed in more detail below.

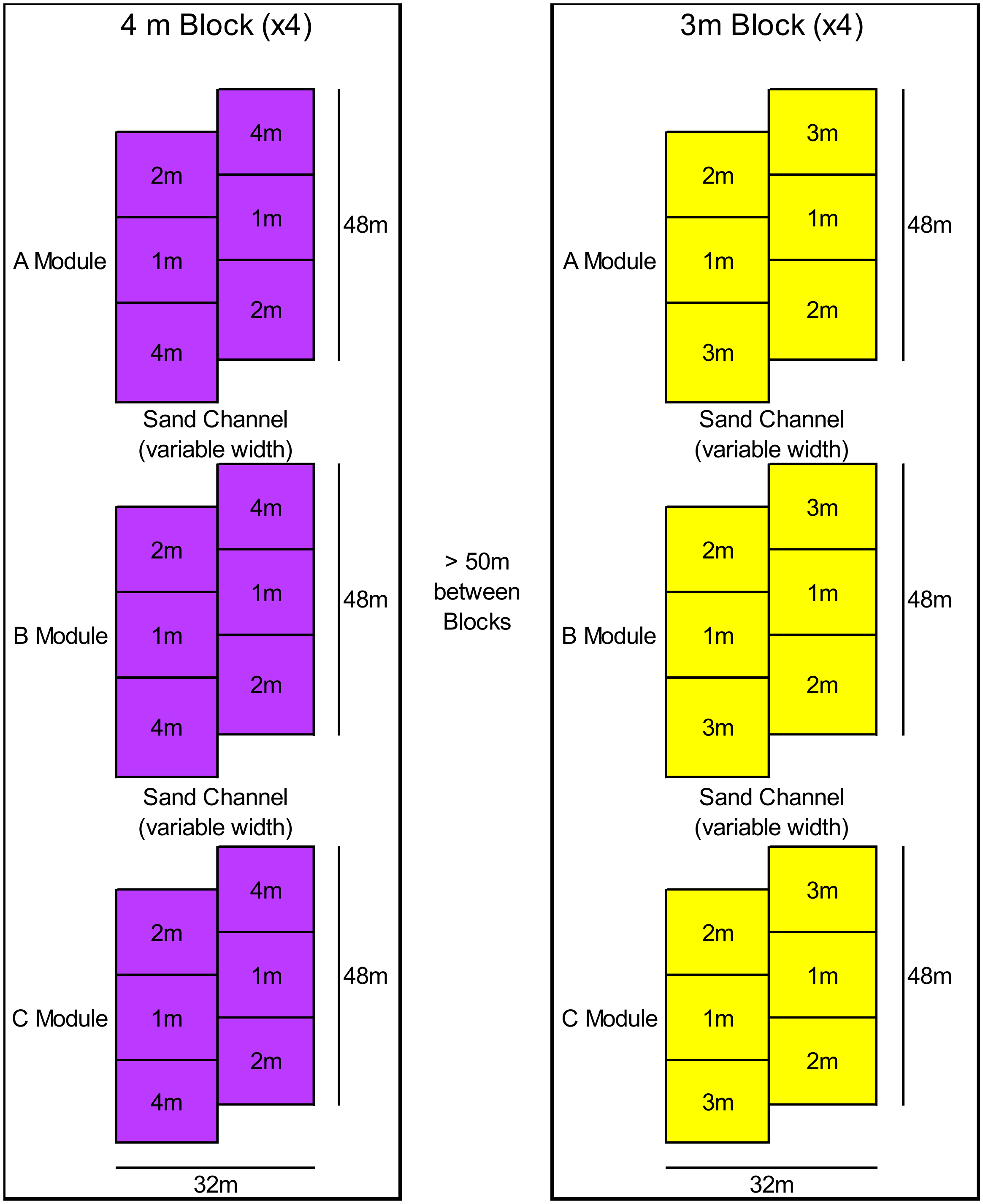

Figure 23. Design of 3m blocks and 4m blocks. Each block contains three modules (A, B, C). Each module consists of a 3 x 2 set of piles, offset by ½ pile length. Each pile is a 16 m x 16 m square pyramid of quarry rock with the overall height listed. There is a 10 to 20 m wide sand channel between modules and at least 50 m of space between blocks (construction design, control and precision details are contained in Appendix I).

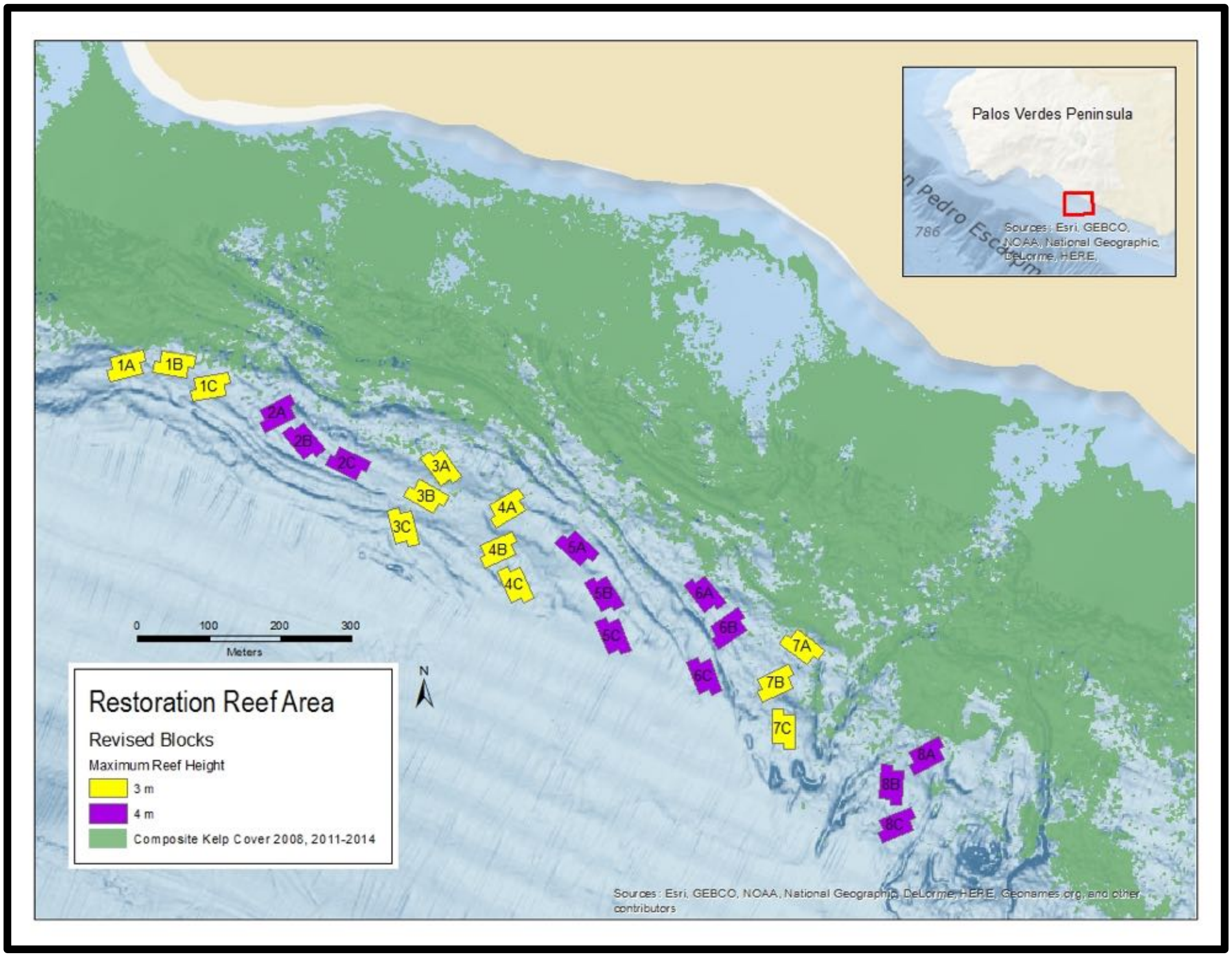

Figure 24. Proposed locations for the restoration reef blocks (1-8) at the Bunker Point restoration site study area with kelp canopy, side scan imagery. Each block consists of 3 modules (A-C). Blocks have a maximum reef height of either 3 m (yellow) or 4 m (purple).

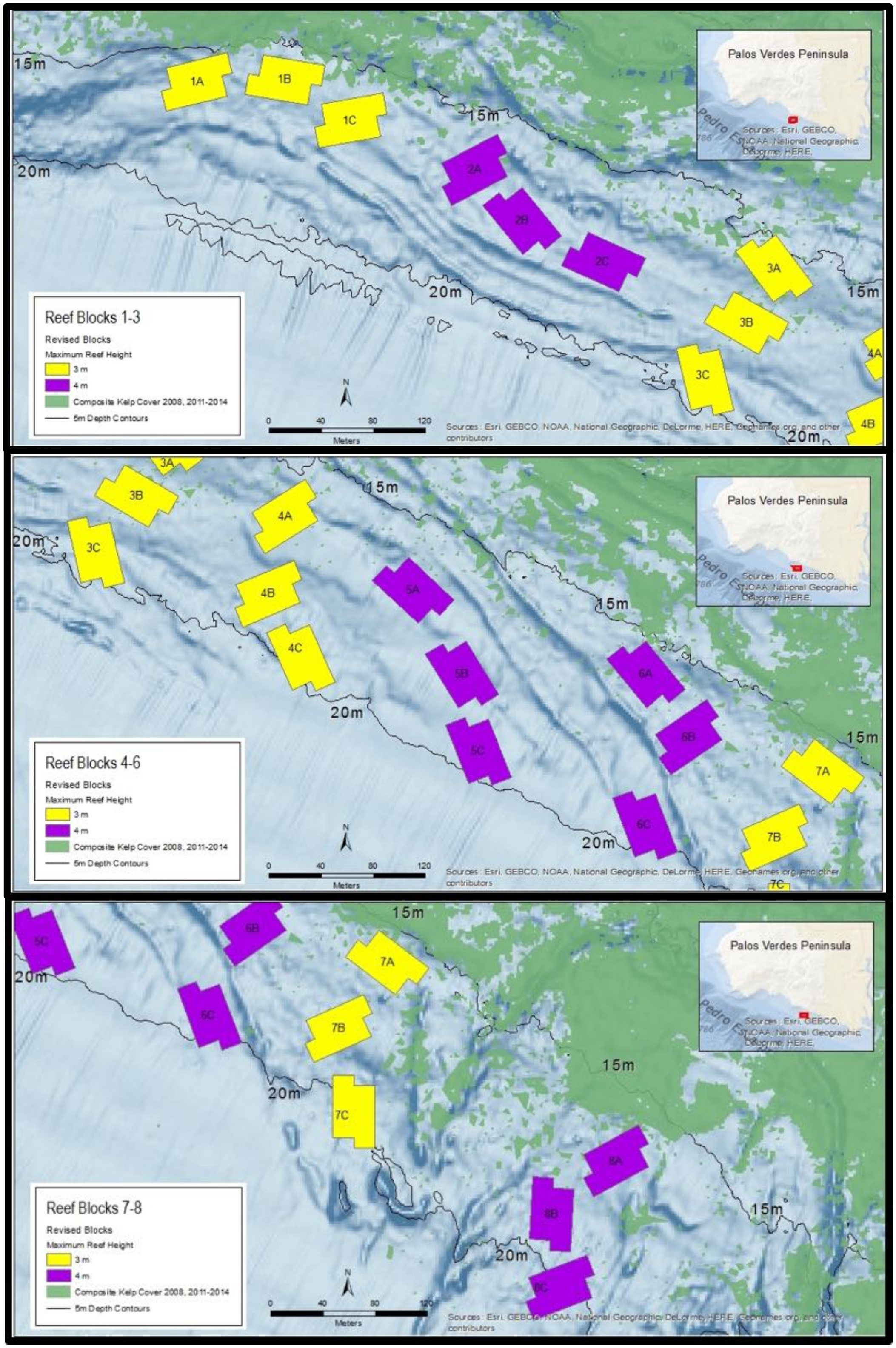

Figure 25. Close-up maps of the proposed locations for the restoration reef blocks (1-8) at the Bunker Point restoration site study area with kelp canopy, side scan imagery. Each block consists of 3 modules (A-C). Blocks have a maximum reef height of either 3 m (yellow) or 4m (purple).

PRIMARY BLOCK DESIGN CRITERIA

Based upon the contractor's estimate, there is 70,000 tons of rock available for this project. Thus, the overall objective is to utilize this limited resource to create the most productive habitat restoring the natural reef environment. The first criteria to consider is quarry rock size and the corresponding weight and void space. The quarry can filter rock sizes within a tight range (more expensive) to variation around a mean size (less expensive) diameters. Considering that this project's goal is to mimic natural reefs, using heterogeneously sized rocks was optimal as natural reefs are not composed of single sized rocks. Designating an average size (weight) within the constraints of the quarry results in the following percent size by weight profiles for rock (Figure 26). A previous study compared elements of fish production on natural and artificial rocky reefs in southern California (Granneman 2011; Granneman and Steele 2014). They found that tissue production was positively correlated with the abundance of large boulders, and they defined large boulders as those being at least 75 cm across. Production was lower on reefs with smaller boulders, most of these being natural reefs and the Wheeler North artificial reef. They explain that the Wheeler North artificial reef was designed with relatively low relief and low rugosity not to maximize fish production, but to mimic natural reefs in the southern Orange County region and to grow kelp. A higher proportion of larger boulders should also increase the likelihood of larger interstitial spaces between rocks in piles creating a variety (i.e., increase heterogeneity) of "hole" sizes for fishes and invertebrates that shelter within (Friedlander and Parrish 1998). Small rocks generally settle tightly, have small void spaces and are not considered as productive as larger rocks proportionally larger void spaces. The estimated average void space increases from 1 ft. to 1.5 ft. as rock size transitions from 0.25 ton to 0.50 tons, and then from 1.5 ft. to 2.0 ft. as rock size increase from 0.5-0.75 ton to 1 ton. Interstitial void space was also considered in the sizing criteria (Table 3). Additionally, having larger stones will minimize the chances of rocks at the edges of blocks from being covered in sediment while creating more complex eco-tone habitats at the sand/rock interface. The other trade-off to consider is that if you model rocks as sphere, as you increase the diameter, you get significantly heavier rocks without correspondingly significantly larger sizes (Figure 27). Note a 2-ton and 3-ton rock are not substantially larger than a 1-ton rock, but 2-3 times the cost, respectively, keeping in mind that weight is the cost estimate used for the quarry. Based upon these criteria, we chose 1.0-ton rock, which has the larger void spaces, is not overly heavy (costly) for our budget, and maximizes the known biological production.

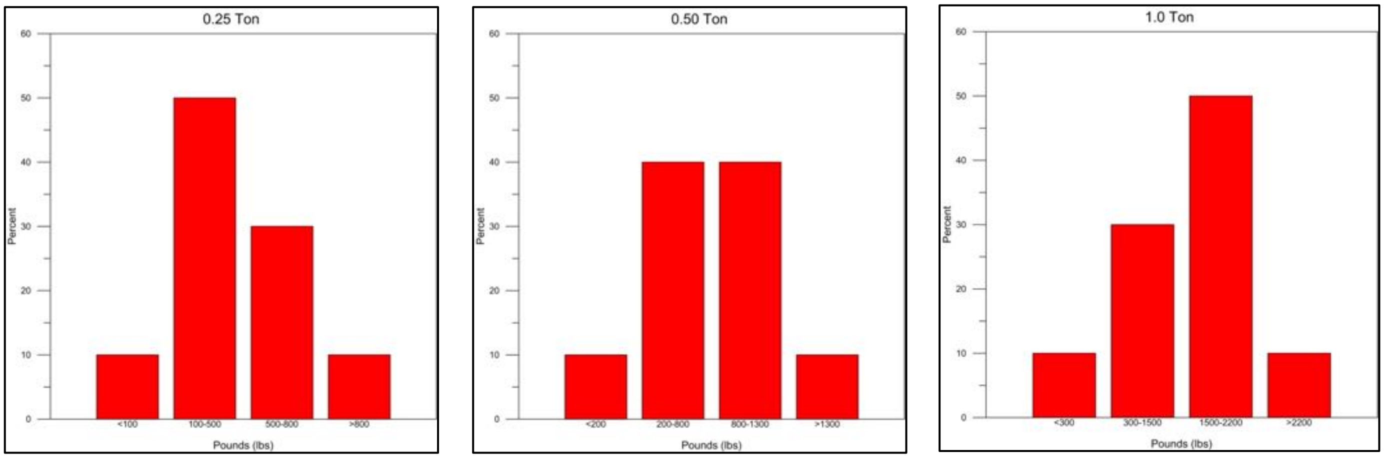

Figure 26. Percent size of quarry rock by weight based upon 0.25, 0.50 and 1.0 ton criteria.

Table 3. Quarry rock weight, dimensions and estimated average void size.

Rock Weight (lbs)	Rock Dimension (ft)	Estimated Average Void Size (ft)
200	1.5 x 1.0 x 1.0	1
300	1.5 x 1.3 x 1.0	
400	1.6 x 1.6 x 1.0	
500	2.0 x 1.5 x 1.0	
1000	3.0 x 2.5 x 2.0	1.5
1500	3.5 x 3.0 x 2.0	
2000	4.0 x 3.0 x 2.5	2
2500	4.0 x 3.5 x 2.5	
3000	4.5 x 3.5 x 2.5	
3500	5.0 x 4.0 x 2.5	

Figure 27. 3-ton, 2-ton and 1-ton quarry rocks arranged left to right.

In addition to optimizing rock sizes, the design of the blocks and modules maximize biological production based upon a variety of physical and biological criteria. First, maximizing the amount of exposed surface area and reef perimeter increase the production versus cost constraints. Engineering constraints dictate that reefs are constructed in a linear fashion as the 6-point barge anchoring systems are used to construct the habitat. Our goal is to design reef that maximize high relief components, surface area, perimeter, flux, and are consistent with the size of reefs along the Palos Verdes Peninsula. High relief reefs have a cost tradeoff, as they are more expensive (more weight per unit area) than low relief reefs. And, a critical consideration is how much rock is buried (and generally unavailable biologically) to create the high relief components. Modules within blocks are designed in 16 m^2 piles where variation in relief is staggered increasing the amount of surface area of the reef. These piles are also staggered maximizing the perimeter of the reef and surrounding ecotone.

The following additional design criteria were incorporated into our module and block designs:

- Stagger high relief piles within blocks. Vary pile heights across adjacent piles within blocks (Figure 23).
  - This should increase diversification of water flow by limiting overlap of high relief piles, reducing the occurrence of one high relief pile being in the "shadow" of another high relief pile. Heterogeneity in pile height may facilitate the creation of a mosaic of small-scale flow features, effectively facilitating microhabitat creation/diversification across the module/block/reef.
  - Maximize external surface area by limiting rock overlap of adjacent high relief piles.
  - Maximize heterogeneity in reef characteristics (e.g., relief, interstitial space, overall angle of outer reef surface) to increase biodiversity by increasing the heterogeneity of available micro-habitats within each block.
- Place high relief piles at the ends of each block to buffer any potential sedimentation of the 1 m relief piles in the middle of each block.
- Size blocks similar to current reefs along Palos Verdes. The pinnacle reef at KOU Rock is ~45m wide, the finger reef at Long Point East is ~120m wide, the finger reef at Point Vicente West is ~225m wide (Figure 8).
- Increase the amount of outer reef edge (the relationship between perimeter and area) by not making blocks too large. The highest biomass areas of the reefs we studied tended to be on the outer edges (zones) (Figure 22).

Block Placement

The following design criteria were used to guide the positioning of restoration reef blocks (and the modules within them) across the Bunker Point restoration site study area:

- Blocks do not overlap with persistent kelp canopy. Persistent kelp canopy is an indication of stable rocky reef below that has not been covered by sediment (Figure 25).
- Blocks are placed at 15-20 m seafloor depth (Figure 25). The highest biomass areas of the reefs we studied tended to be in this depth zone (Figure 22). Placing blocks in these somewhat deeper depths would also limit wave action, scouring and seasonal excavation/deposition of sediments.
- Vary the orientation of each block and each module (Figure 24). This would again increase heterogeneity in reef characteristics, with respect to their relative orientation to the shoreline and to prevailing currents and wave action. This should increase the likelihood of high relief blocks causing creating a mosaic of small-scale flow features,

effectively facilitating microhabitat creation/diversification across the module/block/reef.

- Mimic natural features (reef width and orientation to natural features).
- Blocks placed in a maximum of 1m sediment to limit long-term burial/sinking.
- 10-20 m sand channels between modules within a block (Figures 23-25). Permits space for sediments moving with longshore current and wave action to move around/through modules. Modules are still close enough to provide connectivity (fishes can move over sand between them).
- Maintain connectivity with existing natural reefs. The was done by positioning the ends of at least one module within a block less than 30 m from existing nearshore natural exposed reef (kelp line) or existing (non-buried) rocky reefs so the blocks are not "isolated islands" in the sand (Figure 24-25).
- Maximize distance between blocks (>50 m) to increase independence of each block (Figure 24). Mimics natural reef ridges, these are typically oriented perpendicular to shore with large sandy areas between them.

SECONDARY BLOCK DESIGN CRITERIA

A secondary focus of our reef design was to create a reef design that would permit replicated elements that could be studied to inform future restoration programs (Figures 23-25). This was balanced however, with the primary goal of maximizing the potential for an effective restoration effort. A main question we are interested in examining is the effects of reef relief. Blocks will be in two forms, either with a 3 m overall pile height or a 4 m (Figure 23) overall pile height, with 3 replicate modules per block, and 4 replicate blocks of each height. This will permit a comparison of the two reef heights impact on fish biomass and production. Additionally, with the high level of heterogeneity, but many repeated elements (for example 1m, 2m, 3m and 4m piles, or blocks oriented at various angles relative to shore, or blocks in various seafloor depths), various other studies will also be possible. These could include fine scale habitat utilization patterns, effects of Block orientation relative to current), providing an opportunity to inform future restoration programs in the State.

Figure 28. Example of a 4 m high reef pile, an approximate representation of a module within a block.

RESTORATION REEF DESIGN EVALUATION

We produced simple estimates of the biomass of fishes expected on low (1 m) and higher (2 - 4 m) relief piles within the restoration reef Blocks, then summed these to produce an overall estimate of fish biomass for the restoration reef (Table 4). Fish biomass estimates are based on previously observed biomass densities from Proxy Reef study (Figures 18 & 19).

Table 4. Area and fish biomass estimates for current restoration reef design.

Block Type (Max Relief)	Blocks	Modules Per Block	Pile Relief (m)	Piles per Module	Pile Area 16m x 16m (m2)	Total Area (m2)	Total Area (Acres)	**Fish Biomass Density (g/m2)	Total Biomass (g)	Total Biomass (kg)
		3	4m	2	256	6144	1.5	189	1161216	1161
		3	2m	2	256	6144	1.5	189	1161216	1161
4m	4	3	1m	2	256	6144	1.5	63	387072	387
		3	3m	2	256	6144	1.5	189	1161216	1161
		3	2m	2	256	6144	1.5	189	1161216	1161
3m	4	3	1m	2	256	6144	1.5	63	387072	387
Totals						**36864**	**9.1**		**5419008**	**5419**

**63 g/m^2 is mean biomass for proxy reefs (all quarry rock) < 1.5 m relief and 189 g/m^2 is mean biomass for natural and quarry rock reefs > 1.5 m relief (Figures 18 & 19).

EVALUATION OF ALTERNATIVES

Four design alternatives were considered during initial stages of reef development (Figures 29-32). These used the same 70,000 tons of rock available for this project, but the rocks were placed in other configurations. Alternatives 1 and 2 (Figures 29 & 30) contained large areas of low relief "reef" (<1 or <0.5 m height), essentially individual rocks scattered over the landscape. This type of low relief design was used extensively throughout the Wheeler North artificial reef. However, it was not designed to maximize fish production, but to mimic the low relief natural reefs in the southern Orange County region. In the case of Palos Verdes where sedimentation and reef burial is a major concern, these low relief designs were deemed unlikely to meet the desired restoration objectives as they would likely be heavily impacted by sedimentation scour and burial. Alternatives 3 and 4 (Figures 31 & 32) contained only high relief elements. Early in the design process these alternatives served to motivate discussion of additional design elements (e.g., heterogeneity, spacing, orientation and depth of reef Blocks) that were ultimately included in the final proposed design.

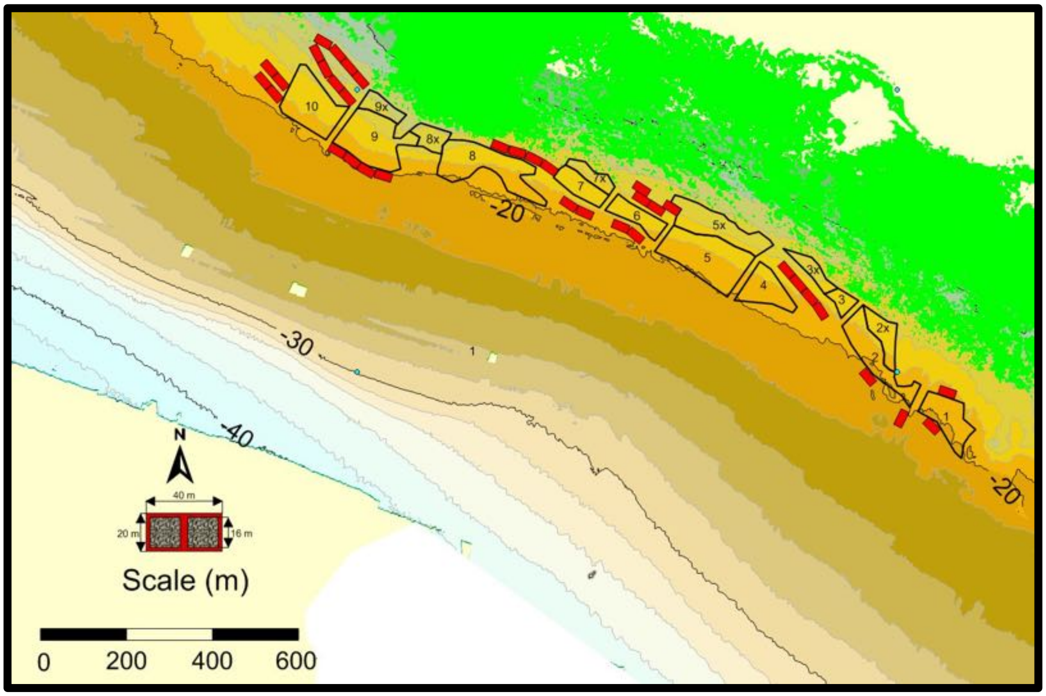

Figure 29. Alternative 1: A reef with high relief components (red polygons) and low relief components (black outlined polygons).

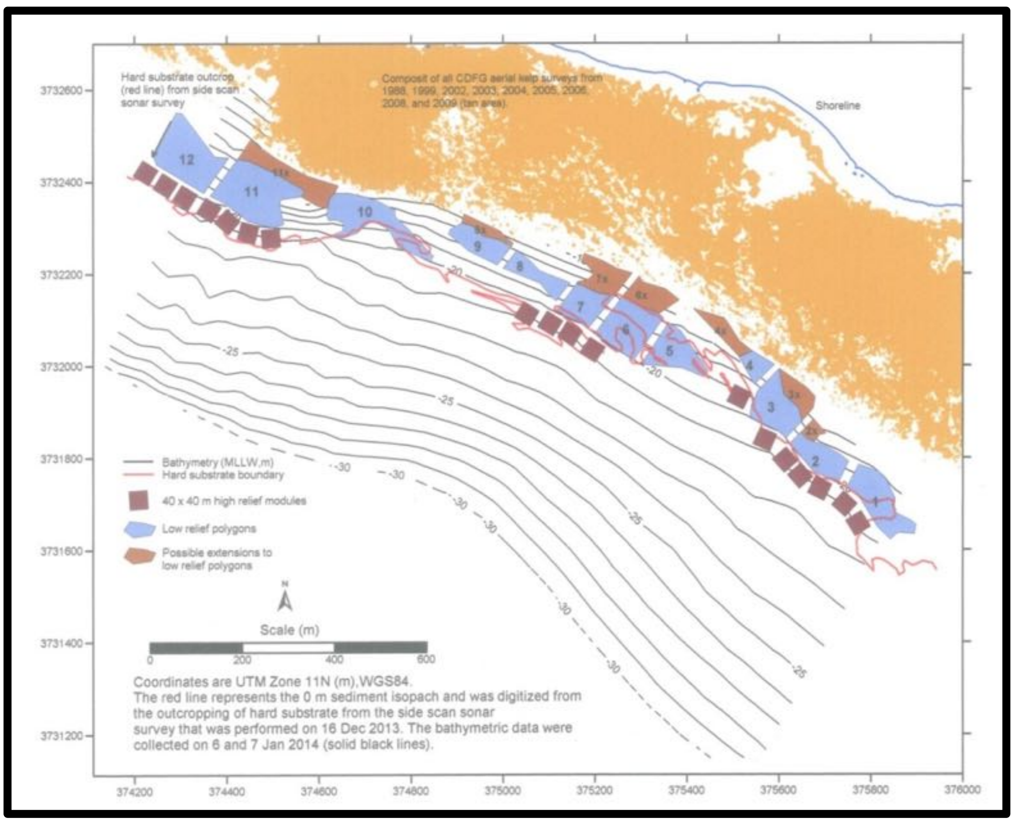

Figure 30. Alternative 2: In this alternative, a reef with high relief components (dark brown square polygons) and low relief components (blue and light brown polygons).

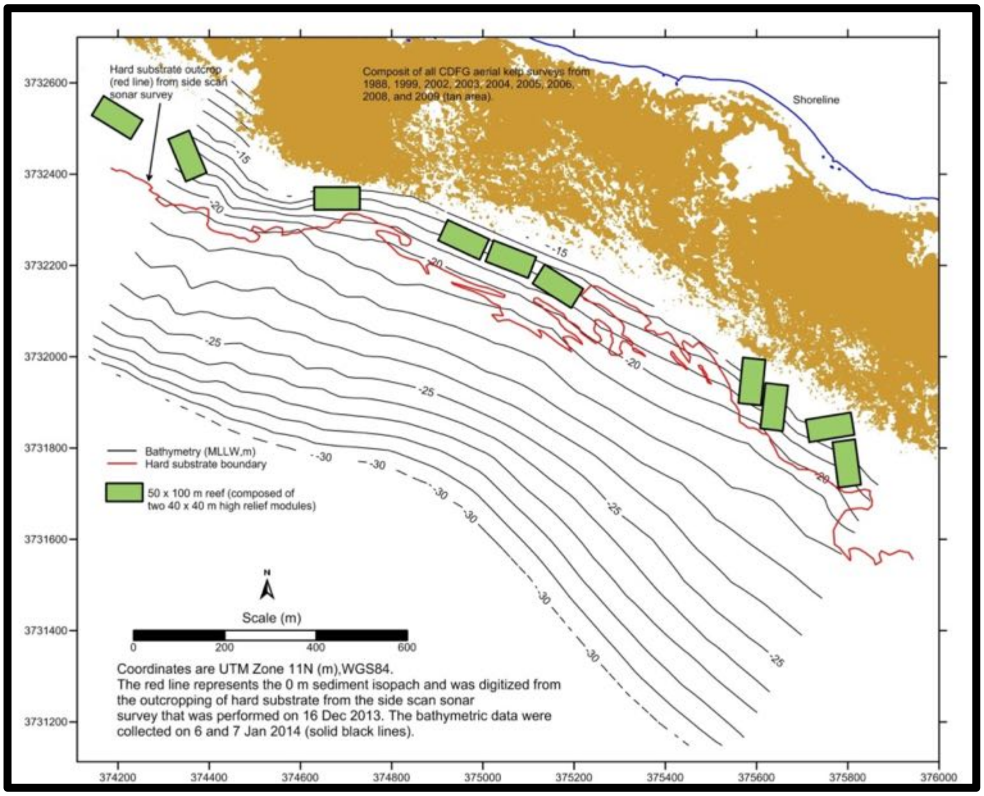

Figure 31. Alternative 3: In this alternative, a reef with high relief components (green polygons) located in shallower water.

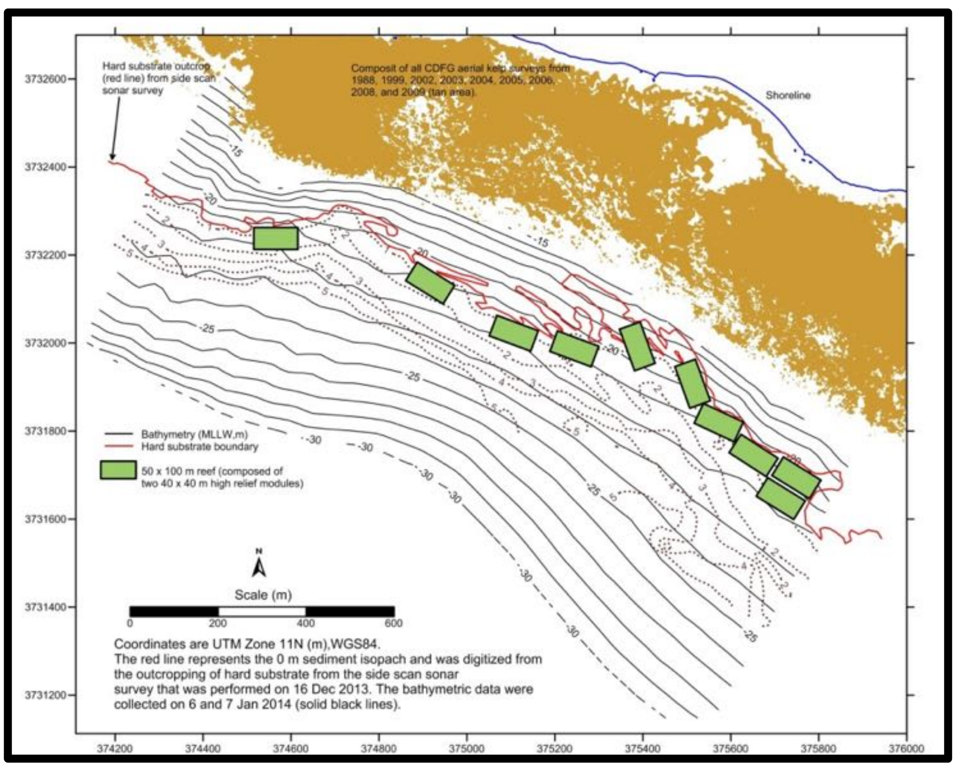

Figure 32. Alternative 4: In this alternative, a reef with high relief components (green polygons) located in deeper water.

GROUND TRUTHING SURVEYS

After the 2013 surveys were completed, it was determined that concentrating semi-contiguous restoration reefs on the west side of KOU Rock, a highly productive and anomalous pinnacle reef in the eastern half of the study area, would be more effective and less confounding to monitoring efforts. The depth of sediment cover on the buried reef between 15 and 20 m was significantly lower than what we found to the east. In addition, there was less slope to the reef increasing the amount of potential restoration habitat between 15-20 m. We determined that this was the optimal placement for the restoration reefs based upon feedback from the resource agencies. Subsequently, all further efforts at surveying the habitat were concentrated on the western side of the survey area. In 2014, eight surveys of the buried reef areas were performed to confirm the interpretation of the geophysical survey results (Figure 33). Divers descended at specific coordinates and swam perpendicular to shore for approximately 200 m. Every 10 m, sediment samples were taken and data was recorded on sediment type, sediment depth (up to 1.8 m), macroalgae, and macroinvertebrates. These data along with video documentation taken during this survey confirmed that the region contained primarily sand and sand-covered reef with scattered small areas of low-relief hard substrate dominated by gorgonians.

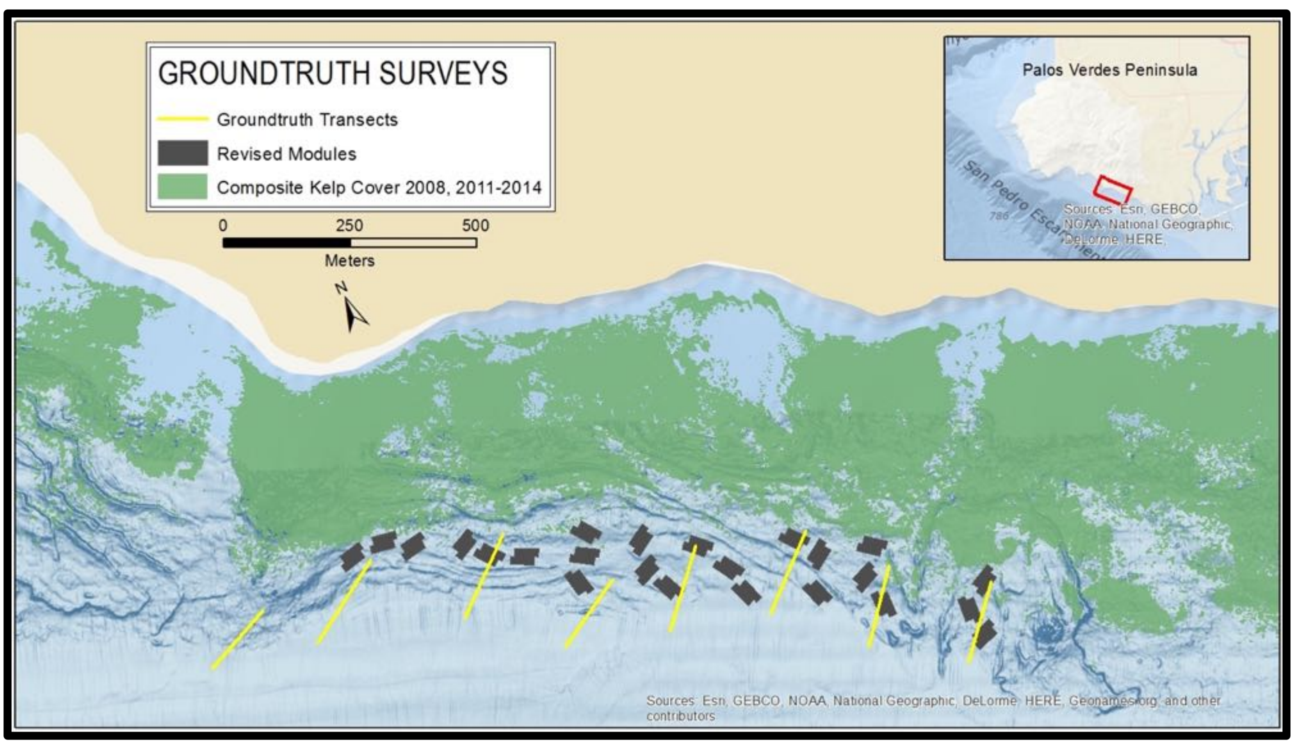

Figure 33. Mapped reef habitat, composite kelp cover, and ground truth transect locations with currently proposed restoration reef Blocks.

SITE INSPECTION SURVEYS

A final site inspection survey of the study area was conducted in 2015 using a simplified version of CRANE protocol (Figure 34). The 26 paired (end-to-end) transects provided information on the substrate composition as well as biological observations. The transect locations were chosen based on: (1) sites that represented areas that are commonly present throughout the proposed area of reef placement, (2) sites that cross ecotones (observed in backscatter data), and (3) sites in likely areas of reef restoration. In summary, 75% of the area was covered by sand (29% had hard substrate within 10 cm of the seafloor), while only a quarter of the substrate was rocky reef. These surveys provided further evidence of burial at specific locations and helped guide Block placement so that existing exposed rocky reef habitat will not be covered during restoration reef construction.

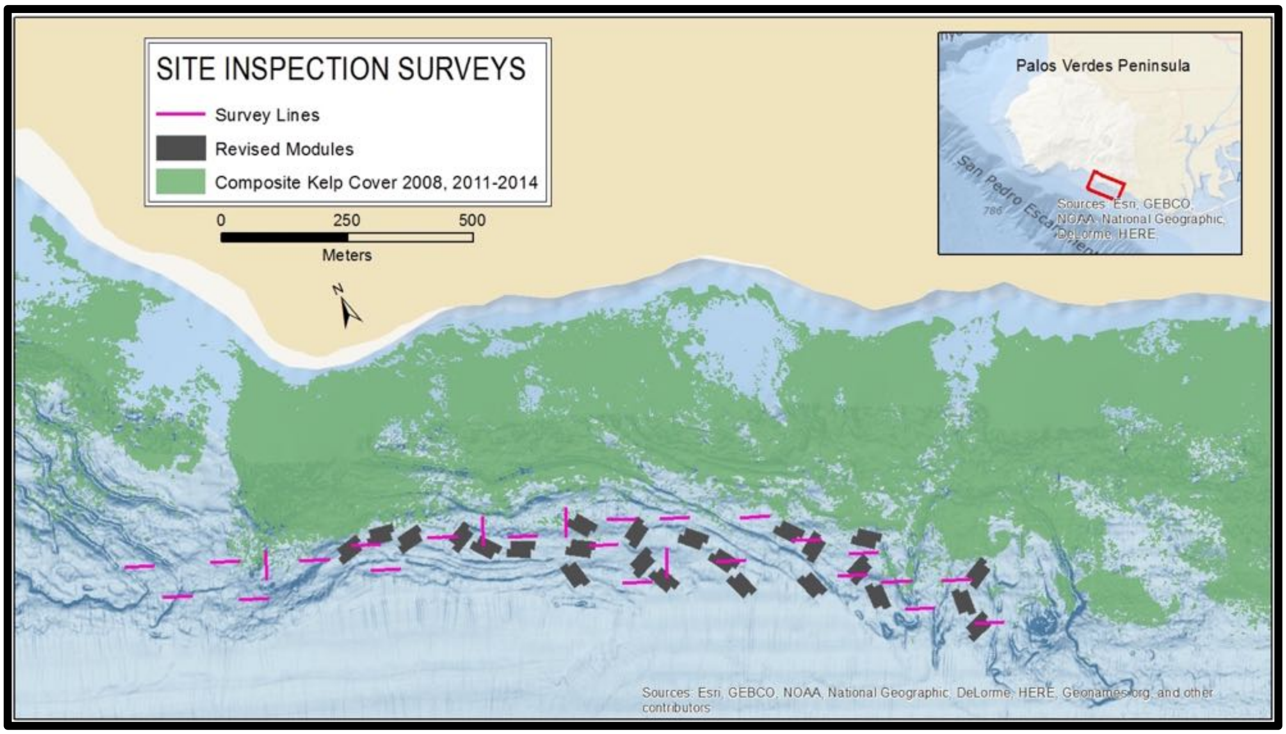

Figure 34. Mapped reef habitat, composite kelp cover, and site inspection survey locations with currently proposed restoration reef Blocks.

MONITORING PLAN

An important step in evaluating the effects of restoration actions along the Palos Verdes Peninsula is to develop an appropriate temporal and spatial sampling design for future monitoring. Short and long-term monitoring of the restoration reef Blocks and sites across the Palos Verdes Peninsula will be critical for evaluating the success of this restoration project and for evaluating the effect of various restoration reef design elements on the associated biological community. Over the first months to years after construction of the restoration reef, we will have the opportunity to measure the level of “attraction” of adult fishes relocating from nearby reefs to the new reef habitat (Figure 35). Over the medium to long-term (3-10 years) monitoring will provide the opportunity to estimate the increase in biomass of important species associated with the restoration reef Blocks, and for whole larger reef complex made up of the restoration reef and the adjacent natural reefs. A Before-After-Control-Impact Paired Series (BACIPS) sampling design (Osenberg et al. 2002) is likely the most appropriate, particularly with respect to also assessing potential changes in biomass due to fish movements (relocation from nearby reefs). This model will help to account for year-to-year environmental variability when assessing changes in biomass. The restoration reef as a whole would likely best be considered an unreplicated “treatment” in this context. While there will be multiple sites sampled within each treatment (i.e., restoration reef, adjacent natural reefs, reference natural reefs), these mostly adjacent sites will not be independent (Table 5; Figures 35). A key to a BACIPS design is having multiple “before” sampling events across sites. Reef construction is currently planned for the fall of 2017. The proposed monitoring design would include three complete rounds of sampling before reef construction (2015, 2016, and 2017 (pre); Table 5). The first round of “After” sampling would begin shortly after the completion of reef construction at the end of 2017 and would be completed in early (likely February) 2018. Subsequently, “after” sampling would be conducted annually for at least 5 years (Table 5). It will likely take at least this length of time for overall changes in biomass due to additional production to be begin to be observed (multiple years of recruitment followed by a few years for those fishes and invertebrates to mature). The restoration reef Modules will be sampled in a similar effort as is used to sample each Depth Zone at a natural reef site (Figure 35). At each module (A, B, C) within each reef block (1-8) we will perform four fish transects (bottom/midwater/canopy portions per transect), two benthic UPC transects, and two benthic swath transects. The quantification of habitat characteristics performed in the CRANE protocol will also permit us to incorporate appropriate methods in the analyses to account for differences in habitat characteristics among sites and treatments (e.g., Miller and Russ 2014).

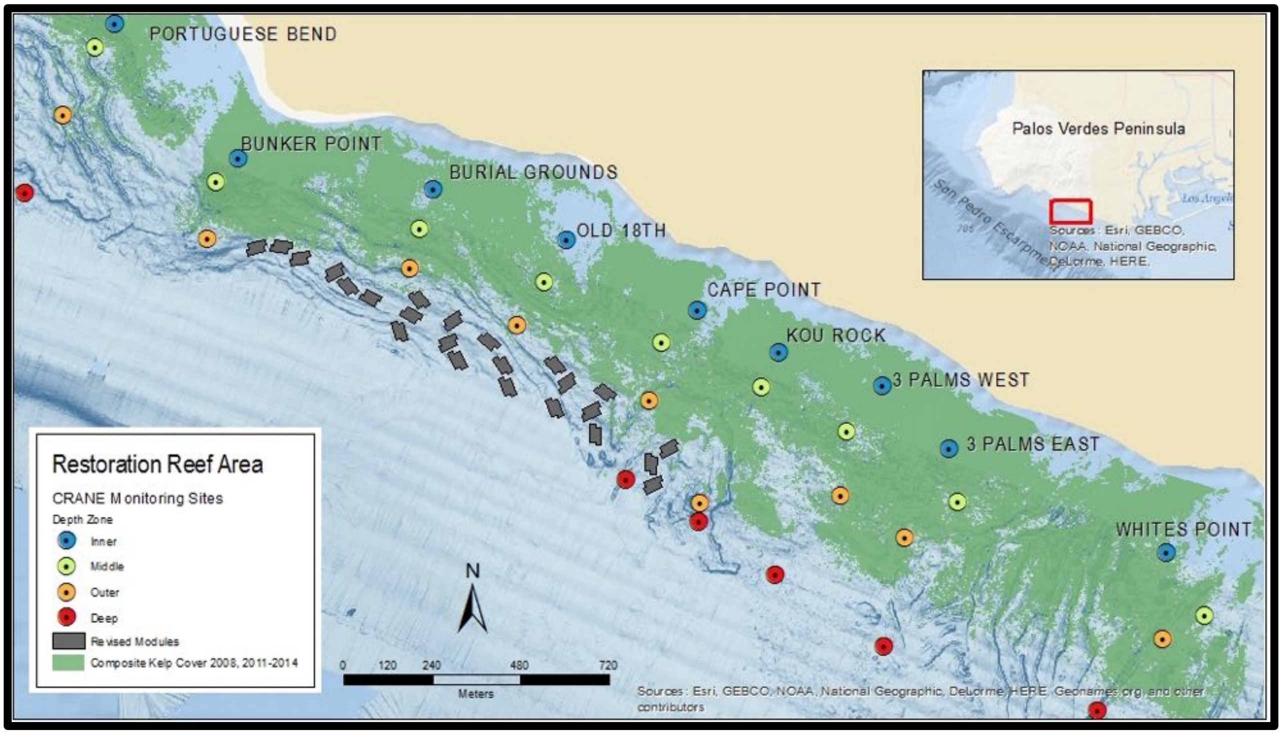

Figure 35. Restoration reef Blocks and CRANE monitoring Sites (individual depth zones indicated) at the Bunker Point restoration site study area with kelp canopy and side scan imagery.

Another part of this assessment is being able determine what proportion of biomass changes are due to fish movements to the restoration reef from the surrounding natural reefs compared with the increase in biomass from additional secondary production of fishes and invertebrates. The proposed sampling design will provide an opportunity to assess the degree to which increases in biomass on the new restoration reef are correlated with decreases in fish biomass on the adjacent natural reefs (Table 5, Figure 35) (Osenberg et al. 2002; Osenberg et al. 2006), suggesting some proportion of the fishes on the restoration reef relocated from nearby reefs. An increase in fish biomass on the restoration reefs and stable or increasing biomass on the adjacent reefs would suggest increased secondary production on entire reef complex. The monitoring data will also permit application of other novel analyses aimed at assessing the levels of 'local production' and 'biomass flux' within the restoration reef system (e.g., Smith et al. 2016). Performing additional studies would provide additional context from which to interpret the monitoring data and provide insight into the mechanisms behind changes in fish biomass in the system. These could include direct assessment of fish movements (e.g., traditional tagging, acoustic telemetry), which would be particularly informative if fishes on adjacent reefs could be tagged prior to reef construction. Other factors influencing fish production, such as increases in growth rates associated with higher relief habitat (e.g., Granneman 2011; Granneman and Steele 2014), could be assessed directly (e.g., through otolith studies for fishes).

Finally, the proposed reef and monitoring designs, with multiple replicated elements, will also provide an opportunity for subsequent studies to examine the effects of restoration reef design features. A primary assessment would be the effect of block relief, 3m versus 4m maximum pile heights, on the associated species biomass and habitat use patterns. Other features that can be assessed may include module orientation or position relative to the coast or dominant current pattern and Block depth. Understanding how these factors impact fish and invertebrate habitat utilization patterns will provide an opportunity to inform future restoration programs in the State.

Table 5. Historical monitoring (with S indicating years sampled) and proposed monitoring (with X indicating sites to be sampled). Sites include (Kelp Restoration) those involved in the kelp restoration project which may contain urchin barrens, be active kelp restoration sites, or sites where the kelp has been restored, (MPA) those within the MPAs that were implemented in 2012, (Within Reef) those located among the proposed restoration reef Blocks, (Adjacent Reef) those located just north or south of the proposed restoration reef, or (Reference) sites that do not currently involve any of the previously mentioned activities or designations. The monitoring plan includes sampling all sites in 2016 prior to reef construction, then once before and once after reef construction in 2017, then annually for at least 5 years after construction. CRANE protocols require >50% coverage of rocky reef, the restoration area has not supported kelp or significant percentages of rocky substrate precluding it from previous CRANE surveys.

		Historical Monitoring										**Proposed Monitoring**			
Site	**Designation**	**2004**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017 (Pre)**	**2017 (Post)**	**2018 - 2022**
Flat Rock North	Reference		S	S							S	X	X		X
Flat Rock South	Reference		S								S	X	X		X
Ridges North	Reference	S	S		S	S	S	S	S	S	S	X	X		X
Ridges South	Reference	S	S	S				S	S	S	S	X	X		X
Rocky Point North	Reference	S	S	S	S		S	S	S	S	S	X	X		X
Rocky Point South	Reference		S			S	S	S	S	S	S	X	X		X
Lunada Bay	Reference						S	S	S		S	X	X	X	X
Resort Point	Kelp Restoration			S				S	S	S	S	X	X		X
Honeymoon Cove	Kelp Restoration						S	S	S	S	S	X	X		X
Segovia	Kelp Restoration							S	S		S	X	X		X
Christmas Tree Cove	Kelp Restoration					S	S	S	S	S	S	X	X	X	X
Marguerite West	Kelp Restoration						S	S	S	S	S	X	X		X
Marguerite Central	Kelp Restoration						S	S	S	S	S	X	X		X
Marguerite East	Kelp Restoration						S	S	S	S	S	X	X		X
Golden Cove	Kelp Restoration						S	S	S	S	S	X	X		X
Underwater Arch	Kelp Restoration					S		S	S		S	X	X		X
Albondigas	Kelp Restoration						S	S	S	S	S	X	X	X	X
Hawthorne Reef	Kelp Restoration		S		S	S	S	S	S	S	S	X	X	X	X
Point Vicente West	MPA	S	S	S	S	S	S	S	S	S	S	X	X		X
Point Vicente East	MPA		S												
Long Point West	MPA		S					S	S		S	X	X		X
Long Point East	MPA		S		S	S	S	S	S	S	S	X	X	X	X
Old Marineland	MPA						S	S	S		S	X	X		X
120 Reef	MPA					S	S	S	S		S	X	X		X
Abalone Cove Kelp West	MPA					S	S	S	S	S	S	X	X		X
Abalone Cove Kelp East	MPA					S		S							
Portuguese Point	MPA					S		S	S		S	X	X		X
Portuguese Bend	Adjacent Reef								S		S	X	X	X	X
Bunker Point	Adjacent Reef		S				S	S	S	S	S	X	X	X	X
Burial Grounds	Within Reef										S	X	X	X	X
Old 18th	Within Reef								S		S	X	X	X	X
Cape Point	Within Reef										S	X	X	X	X
KOU Rock	Adjacent Reef				S		S	S	S	S	S	X	X	X	X
3 Palms West	Adjacent Reef		S						S	S	S	X	X	X	X
3 Palms East	Adjacent Reef		S	S	S					S	S	X	X	X	X
Whites Point	Reference		S	S		S	S	S	S	S	S	X	X	X	X
Cairns	Reference						S	S	S	S	S	X	X	X	X
Point Fermin	Reference		S	S		S	S	S	S	S	S	X	X	X	X

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